DISCOVERY

A Monthly Popular Journal of Knowledge

ANNIVERSARY NUMBER

Vol. XIV. No. 160. APRIL, 1933. 1s. NET

PRINCIPAL CONTENTS

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Trustees: Sir J. J. Thomson, O.M., F.R.S., Sir F. G. Kenyon, K.C.B., F.B.A., Professor A. C. Seward, Sc.D., F.R.S., Professor R. S. Conway, Litt.D., F.B.A.

Edited by Bernard Lintern.

Publishers: Benn Brothers, Ltd. All communications respecting editorial matters to be addressed to the Editor; all questions of advertisements and subscriptions to the Manager.

Offices: Bouverie House, Fleet Street, London, E.C.4. (Closed on Saturday.)

Telephone City 0244. Telegrams: Benbrolish, Fleet, London.

Annual Subscriptions 12*s.* 6*d.* post free anywhere in the world. Single numbers 1*s.* net; single back numbers more than two years old, 1*s.* 6*d.* net; postage (inland and foreign) 2*d.*

Binding cases, price 2*s.* 6*d.* net each; postage 6*d.*

Notes of the Month.

With this number *Discovery* celebrates another anniversary. Since 1920 it has maintained a unique position among English magazines, and its pages have formed a complete record of progress in almost every branch of science. Perhaps the most exciting discoveries of the post-war years have been in the field of atomic physics. In this issue we are privileged to publish an important article by Lord Rutherford, who reviews the experiments in the transmutation of the elements at the Cavendish Laboratory, Cambridge. This remarkable work has aroused widespread interest, and we are fortunate in obtaining a full account from so eminent a contributor. Dr. Cockcroft, who has been prominently associated with the work, has assisted in the preparation of the article.

* * * * *

Next month we shall publish an article of special interest from Professor R. S. Conway. Having seen, during a recent visit to Tunis, the remarkable mosaic containing a portrait of Vergil which was discovered in North Africa some 30 years ago, he has now obtained a photographic reproduction for this journal. The head of Vergil was sketched for a recent edition of the Aeneid; but the whole picture, though known to scholars, has never been reproduced in England, and *Discovery* is now able to make it available for the first time. Professor Conway gives reasons for believing it to be an authentic likeness of Vergil, and shows how it illuminates many points in the personality of the poet. Our photograph is from a water-colour painting copied from the original mosaic by M. Pradère, director of the Bardo Museum at Tunis, and obviously, its first reproduction in *Discovery* will make an immediate appeal both to classical scholars and to schools. The picture will occupy a full page and will be suitable for framing. We are arranging to print extra copies of the May issue to meet the increased demand, but it will greatly assist arrangements if orders are sent to the publishers in advance.

* * * * *

We much regret to learn of the disaster to Captain Riiser Larsen's Antarctic expedition. The party had previously been reported to have established itself on the Ice Barrier but news was later received at Oslo that the expedition had been broken up by ice. Captain Larsen and his companions were fortunately rescued by a Norwegian whaler and most of the equipment has been saved, but they report the sad loss of all their dogs. The party has now returned to Norway. Captain Wistling, who was a companion of Captain Amundsen in the discovery of the South Pole, has expressed the opinion that the expedition probably never reached firm ice but landed on the ice-edge, which broke off and drifted out to sea. Captain Larsen's own story of the disaster has not yet been made known. As reported in *Discovery* last January, the expedition had hoped to reach Enderby land, and then to travel westwards to the Weddell Sea, a distance of 3,500 miles. Nearly 2,000 miles of this journey would have lain across unexplored regions. Captain Larsen had hoped to solve the question of whether there is an opening from the Weddell Sea, through unknown regions, to the Ross Sea.

* * * * *

Evidence of a vanished race of pygmies in the Northern Transvaal is the result of important discoveries made by Mr. D. S. van der Merwe, assistant registrar of mining titles on the Rand. According to the Johannesburg *Sunday Times* the finds include sacrificial graves of an entirely new type, a sacrificial altar approached

by staircases so small that they could only have been used by pygmies, an irrigation system of enormous extent, remnants of a large dam made by a vanished race, and an authentic mining implement used by unknown copper miners of the Palabara. Mr. van der Merwe has photographed and measured his discoveries with extreme care, and his collection is believed to be the most complete and systematic ever made by a layman. It has been placed at the disposal of the Department of Ethnology in the University of Witwatersrand, where it is regarded as highly important.

* * * * *

As a result of the Oxford Exploration Club's expedition to Sarawak the British Museum (Natural History) will receive a valuable collection of birds, insects, reptiles and plants. During a stay of seven months in the country, a considerable area was mapped, mountains climbed, and extensive studies made of the Kayan and other tribes of the interior, of which the customs had not previously been recorded. Among the Kayans, the remnants of the ceremonies formerly observed in connexion with head hunting were recorded. As it is a good many years since the wild tribes of Sarawak were visited and described by Dr. W. McDougall and the late Dr. Charles Hose, the ethnological results of the expedition should be of particular interest.

* * * * *

The discovery of a mosaic pavement at Daphne, near Antioch, is announced by Professor George W. Elderkin in an American publication. The neighbourhood is being excavated under the auspices of Princeton University, and the earlier find of an excellent mosaic in the ruins of a Roman house at Antioch itself was described by Professor C. R. Morey in *Discovery* last December. Following so soon upon this, the new discovery augurs well for the future. Antioch, indeed, promises to rival the towns of Roman Tunisia in its wealth of mosaic pavements. The date of the new find can at present be stated only approximately ; the style of the work is the only guide, but it is thought that the pavement belongs to the late third or fourth centuries. There is no Christian suggestion in the scenes, which represent encounters with animals arranged to be seen successively as one walked along the border. Further details will be awaited with interest.

* * * * *

Although primarily an engineering problem, safety in the streets is considerably influenced by psychological considerations. Recent research has shown, for instance, that the human factor is responsible for nearly ninety per cent of motor accidents in the United States, and that the causes attributed to defects in the highway or the vehicle are of relatively small importance. When it is realized that in the United States there is an incredible annual toll of 34,000 lives and a million injuries as a result of street accidents, the importance of the comparatively new " highway research " may be realized.

* * * * *

Professor Steinburg, of the University of Maryland, recently gave a broadcast talk on the developments in these investigations. A psychological study was made at the Iowa State College of 2,000 drivers. They were tested on a specially constructed road as to their action when lights, signals, direction and warning signs were encountered. The results showed that the drivers could be divided into three classes. The first class consists of the " accident free " drivers and comprises about seventy-five per cent of those tested. The second group numbers about twenty per cent of the total and contains the " accident liable " drivers who give trouble from various causes. Some are irresponsible, some are preoccupied through illness or personal affairs, while others are careless. Their failure arises either from heredity or environment and renders it necessary for the highway engineer to provide fool-proof roads. The third small group generally suffer from some defect such as colour blindness, restricted field of vision, double vision of a single object, or extreme nervousness and poor co-ordination. Professor Steinburg has made the interesting discovery that half the total accidents are caused by only about seven per cent of all the drivers.

* * * * *

Recent events have demonstrated the need for the scientific study of explosions. With the aid of a high speed camera made by Mr. R. P. Fraser at the Imperial College of Science, it is now possible to photograph and accurately analyse movements in explosion flames occurring with frequencies up to a million a second. This is in itself a remarkable achievement apart from the importance of its applications. A number of the photographs were shown by Professor W. A. Bone to illustrate a lecture at the Royal Institution. The photographs show the influence of compression waves in accelerating explosion flames, and also reveal the existence of a body of positively charged particles which spiral through the medium with a frequency of several tens of thousands a second. These developments have opened up a new field in the investigation of chemical change in gaseous substances under the most intensive conditions of temperature and pressure.

The Transmutation of the Elements.

By Lord Rutherford of Nelson, O.M.

The recent discovery by Cockcroft and Walton that high velocity protons have a remarkable potency in producing atomic transmutations has led to a great extension of interest in this field. We are privileged to publish this article by Lord Rutherford, who reviews the various experimental methods now being developed for this research.

MANY of the laboratories of the world are now being equipped for an attack on the atomic nucleus on the lines of the discovery by Cockcroft and Walton at the Cavendish Laboratory. In order to produce an atomic transmutation, it is necessary to change in some way the structure of the nucleus; to add to or extract from the nucleus one of its constituent particles, whether a proton, neutron, alpha-particle or electron, or to substitute one of these particles for one of the existing units of the nuclear structure. The first essential is, therefore, to cause one of these particles to penetrate the atomic nucleus, and for this it is necessary to have particles moving with very high velocities—of the order of 10,000 kms/sec.—in order that they shall be able to pass through the formidable defences of the nucleus.

The first experiments, carried out in the Cavendish Laboratory in 1919 by Rutherford and Chadwick, showed that when certain light elements were bombarded by the alpha-particles which are expelled from the radioactive bodies, an alpha-particle occasionally entered a nucleus, leading to the expulsion from it of a swift proton. Since, however, the chance of an alpha-particle hitting a nucleus is exceedingly small, on an average only about one alpha-particle in a million was effective in disintegrating the nucleus. The more recent experiments show that protons having velocities as low as 3,000 kms/sec. can penetrate the nucleus of the light elements lithium and boron, and for this speed about one proton in 100,000 million enters a nucleus and results in the expulsion of a swift alpha-particle.

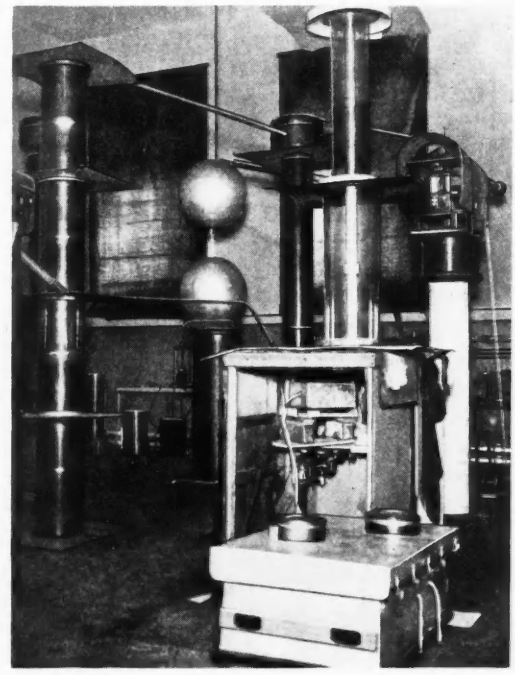


FIG. 1.
The high voltage generator and tube for accelerating protons, used by Cockcoft and Walton at the Cavendish Laboratory.

Since the probability of a proton entering a nucleus diminishes with decreasing velocity and with increasing weight of the nucleus bombarded, it is important to obtain very intense sources of protons moving with the highest speeds which can be produced conveniently in the laboratory. Thus, if we produce a stream of protons conveying a current of one-millionth of an ampere, corresponding to six million million projectiles per second, to obtain an equal number of alpha-particles 160 grams of radium would be required. If the protons are accelerated by applying 600,000 volts, they reach a speed of ten thousand kilometres per second, a speed adequate to secure the transformation of many light elements.

The developments of the apparatus in the Cavendish Laboratory has been based largely on a theory which was put forward by Gamow to account for the penetration of alpha-particles into the nucleus. Gamow's theory showed that, whilst alpha-particles would require to be accelerated by potentials of the order of five million volts to penetrate a light nucleus, protons accelerated by one-tenth of this voltage ought to be almost as efficient, owing to their smaller mass and charge. The construction of an apparatus which was ultimately to be capable of accelerating protons by potentials of at least 600 thousand volts was therefore commenced in 1928. At the outset a choice had to be made between the different types of high voltage apparatus which could be used for the work; as might perhaps be expected, the simplicity of the apparatus required was in inverse ratio to the experimental convenience. Thus

voltages of the order of 600,000 to a million can be produced very easily and cheaply by a Tesla Coil, but unfortunately the voltage alternates rapidly in intensity, and the time during which the voltage is at its maximum value is seldom more than one-thousandth of the total working time, so that on the average only weak streams of particles can be obtained.

It was decided from the first, therefore, to work with steady potentials and to develop a direct current generator for 600,000 volts. A photograph of this generator is shown in Fig. 1. It consists of a tower of four glass cylinders, each 1 foot in diameter and 3 feet long, each cylinder possessing a pair of electrodes and a hot tungsten filament so that it can act as a high voltage diode valve. A high vacuum is maintained in the tower by oil diffusion pumps placed below the floor, and connexions are made to a high voltage transformer giving a potential of 200,000 volts, and to four condensers. These connexions are so arranged that the voltage of the transformer is multiplied by a factor between three and four, and a steady voltage of 600,000 to 700,000 is produced between the top of the tower and the ground. This potential is then applied to the experimental apparatus shown in Fig. 2, in which the protons are accelerated. The protons are generated by an electric discharge through the small tube D containing hydrogen at low pressure, and some of these protons pass through a tubular opening at the base into the large tubes B, to which the accelerating voltage is applied. The tubes B are kept at a very low vacuum by means of fast pumps. The protons, which reach a high speed in passing through the strong electric field in B, bombard targets of different metals placed at the end of the chamber, and the resulting effects of this bombardment are carefully studied.

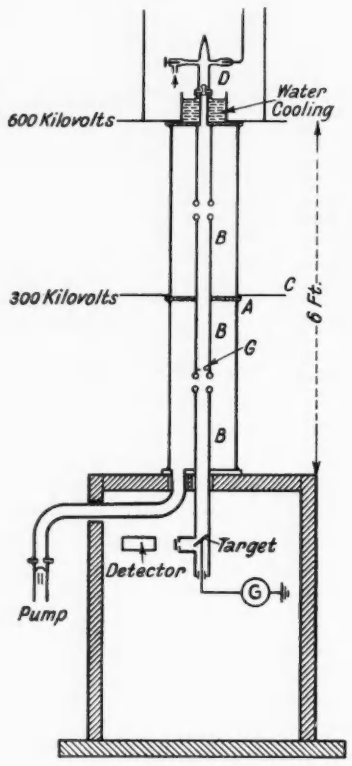


Fig. 2.
Apparatus used by Cockcroft and Walton for atomic disintegration by high speed protons.

A generator of rather different type is shown in Fig. 3 and has been developed to the design of Van der Graaf in Washington. A metal sphere, 12 feet in diameter, is supported on an insulating pedestal; into and out of the sphere passes a travelling silk belt which is charged with electricity at the base. The charge adheres to the silk and is carried up into the sphere by the motion of the belt. The sphere therefore obtains a gradually increasing charge and rises in potential until an equilibrium is established between the leakage of charge from the sphere and the charge conveyed by the belt. With this generator, it is hoped to produce currents of the order of 1 milliampere at 5 to 10 million volts, and to insert a large vacuum tube between the sphere and ground for nuclear bombardment. A smaller generator, providing 200 microamperes at 1.5 million volts, has already been produced on the same principle, and a still larger generator is being built in the Massachusetts Institute of Technology. The great attraction of this generator is, of course, its extreme simplicity; its disadvantages on the other hand appear to lie in the small magnitude of the currents which can be produced compared with the leakages which usually occur at high potentials; it will, therefore, be of great interest to watch its development and to see whether these drawbacks can be overcome.

Another line of attack has been developed by Brasch and Lange in Berlin. By charging a number of condensers in parallel and discharging them in series, voltages of up to five million have been produced for commercial tests, these voltages rising to a maximum value in about a millionth of a second, persisting for a few hundred-thousandths of a second, and then dying down. Voltages of this type, known as impulsive voltages, have the advantage that they can be applied to apparatus of much smaller dimensions than is possible for the case of steady voltages. Thus, Brasch and Lange have recently applied such voltages to tubes only 75 cms. long, and have been able to produce fast particles for experimental purposes. Owing to the very short time during which the voltage is applied, many of the usual experimental methods of studying disintegration processes would appear to be excluded, and special methods will no doubt have to be developed for this work.

A very ingenious method of producing high velocity particles has recently been developed by Lawrence in the United States. The particles move in a spiral path between the poles of a large electromagnet, and receive electrical impulses twice in each revolution from a high frequency oscillator developing perhaps 10,000 volts. Thus, after completing 200 revolutions of the spiral, the particles will have the same velocity as though they had been accelerated directly by four million volts. With this apparatus the results of Cockcroft and Walton have been confirmed and extended to higher voltages.

We must now pass on to consider the types of transformation that are produced by the bombardment of elements by swift alpha-particles and protons. In the case of bombardment by alpha-particles, it seems clear that an alpha-particle occasionally enters a nucleus and is captured. The violent disturbance produced results in the expulsion of one of the constituent protons with high speed. In illustration consider the effects observed in nitrogen. The alpha-particle, which is a helium nucleus of mass 4 carrying two charges, is captured by the nitrogen nucleus of mass 14 and charge 7, while a proton of mass 1 and charge 1 is expelled. The changes occurring are illustrated by the following relation: $N_{14}+He_4=O_{17}+H_1$. As a result of the transformation, a new nucleus is formed of mass 17 and charge 8 which is a known isotope of oxygen. It is important to note that as a result of this transformation a new atom is formed of mass 3 units heavier and charge 1 unit higher than the bombarded atom. A similar type of transformation appears to occur in about a dozen of the light elements.

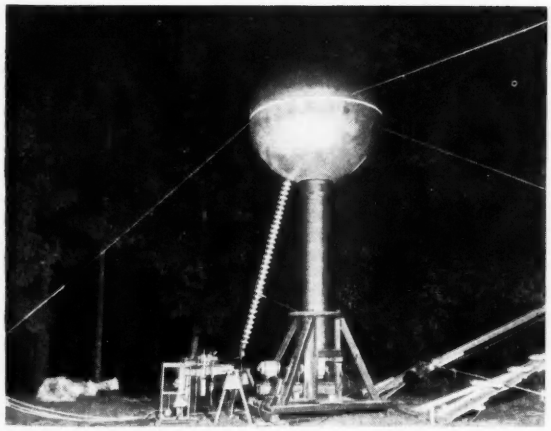


FIG. 3.
The electrostatic generator designed by Van der Graaf of Washington. With this it is hoped to generate currents of five million volts.

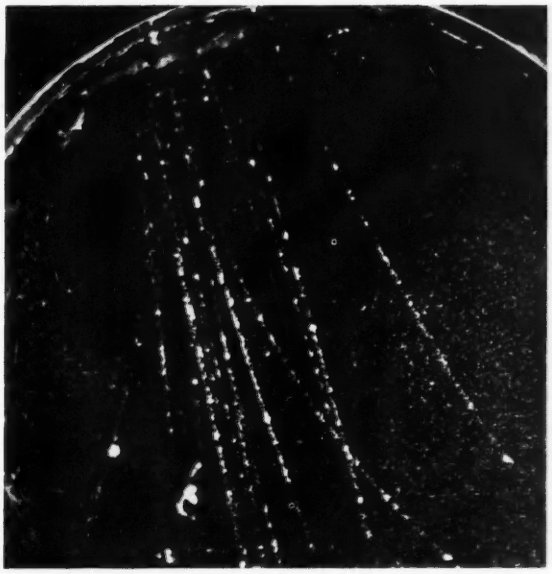


FIG. 4.
A Wilson chamber photograph taken by Blackett and Occhialini, showing a shower of high speed particles resulting from a disintegration.

Another remarkable type of transformation by alpha-rays has been brought to light in the past year. When alpha-rays fall on the light element beryllium no protons are emitted, but Bothe observed what appeared to be a very penetrating radiation. This radiation was shown by M. and Mme. Curie-Joliot to have strange properties. Chadwick concluded that the radiation was not of the gamma-ray type at all, but consisted of streams of particles of a new type which had a mass about equal to that of the proton, but which had no electric charge.

In consequence of its lack of charge, the neutron, as it has been termed, can pass freely through the outer structure of the atoms and can penetrate great thicknesses of matter. It produces little or no ionization in a gas through which it passes, but makes its presence evident when it collides with a nucleus. This recoiling nucleus, on the other hand, is an efficient ionizer and so can be detected either by its electrical effect or its track can be photographed in an expansion chamber. The energy of recoil is greatest when it strikes a hydrogen nucleus, and the recoiling atom may travel 30 c.m. or more in air before it is brought to rest. It seems that the transformation which results from the capture of an alpha-particle is $Be_9+He_4=C_{12}+$neutron, so that a carbon nucleus is formed while a neutron is expelled with high speed.

Feather has shown that the neutron is itself a very efficient projectile for transforming other atoms. For

example, photographs taken in an expansion chamber show that occasionally a nitrogen nucleus is disintegrated by a neutron with the emission of an alpha-particle. Oxygen, which does not seem to be affected by bombardment either by alpha-particles or protons, is readily disintegrated by a neutron with the emission of an alpha-particle, apparently according to the relation $O_{16}+\text{neutron}_1=He_4+C_{13}$, an isotope of carbon of mass 13 being formed by the process. It will be of very great interest to examine whether other elements can be transformed by this new type of projectile, but the experiments are somewhat difficult and laborious.

Protons and Light Metals.

The disintegrations produced by the impact of protons on the light metals are, on the other hand, much more numerous, and thus easier to examine. In most of the cases which have been studied up to the present it has been found that when a proton enters a nucleus an alpha-particle is expelled. The transmutation is thus exactly the reverse process to the alpha-particle transmutation when a proton is ejected. The alpha-particles can be detected by the scintillations which they produce on a fluorescent screen, by passing them into an expansion chamber, or by the more precise electrical recording methods. By the latter method it is possible to study the ionization which the particles produce in passing through gases, and so to determine their nature with a considerable degree of certainty.

The first transformation studied was that of lithium. In this case it was found that a group of alpha-particles was ejected with velocities of 20,000 Km/sec.; and that for an accelerating potential of 500,000 volts about one proton in a hundred million was effective in producing a transmutation. Since lithium is a mixture of two isotopes of masses 6 and 7 of which the second is most abundant, it seemed reasonable to assume that the proton entered a lithium nucleus of mass 7 and that the resulting nucleus broke up into two alpha-particles, $Li_7+H_1=He_4+He_4$. A test of this hypothesis is possible from the energies of the incident protons and the ejected alpha-particles. Since the energy of the alpha-particles may be 200 times greater than the energy of the proton, it seems probable that the additional kinetic energy comes from a loss of mass which takes place in the transmutation, since by Einstein's equation mass and energy are interchangeable.

Now the masses of the helium and hydrogen nuclei and of the lithium isotope are known with a fair degree of precision from mass spectrograph measurements, and we find that the loss of mass is in quite reasonable agreement with the observed kinetic energies. In addition to the high velocity group of alpha-particles, it has recently been found that a low velocity group is ejected, and that a gamma-ray is also produced by the transmutation. Although measurements of the energy of the gamma-rays have not yet been made, it seems likely that it will be connected with the difference in energies of the two alpha-ray groups.

The next disintegration of importance which was studied was that of boron. In this case it seems likely that the following relation holds: $B_{11}+H_1=3\times He_4$. In other words the boron isotope of mass 11 occasionally captures a proton and breaks up into three alpha-particles. At present the main argument in favour of this hypothesis comes from the agreement of the observed energies of the particles with the mass changes in the transmutation. It is, however, very desirable to obtain confirmation of this by other means, and experiments are in progress to this end. In the case of boron, the number of disintegrations produced at 500 kilovolts is much larger than with lithium, one proton in two million producing a disintegration. On the other hand, observable numbers of disintegrations can be produced by voltages as low as 60,000 provided large proton currents are used.

In addition to the detailed study of lithium and boron, a rough survey has been made by Cockcroft and Walton of the effect of bombarding other elements by protons. In general, it seems that the lighter elements whose atomic weights can be expressed as $(4n+3)$, where n is an integer, are relatively easy to disintegrate, and in all cases an alpha-particle seems to be emitted. Thus in the case of fluorine and aluminium we probably have the following reactions: $\text{Fluorine}_{19}+H_1=O_{16}+He_4$; and $\text{Aluminium}_{27}+H_1=\text{Magnesium}_{24}+He_4$.

Other Elements.

Alpha-particles have also been observed in the bombardment of other elements including carbon, nitrogen, phosphorus, cadmium, copper, nickel and cobalt. In all these cases, however, the number of particles emitted is small and very great care has to be taken to exclude the possibility of the results being due to impurities. Thus if a monomolecular layer of boron were to exist on a surface, it would give as many alpha-particles as are observed from elements such as copper. It is clear, therefore, that a great deal of careful and detailed work will be necessary before authoritative statements can be made about the heavier elements.

(*Concluded on page* 128.)

The "White Coal" of Canada.

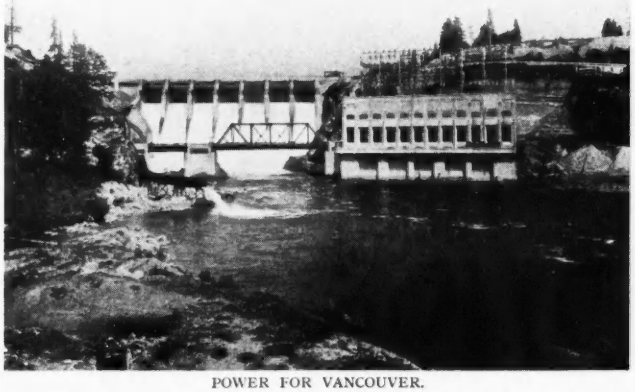
By E. Geoffrey Cullwick.

Assistant Professor of Electrical Engineering, University of British Columbia.

The water power of Canada is one of the greatest in the world; it is estimated that over thirty million horse-power is available, of which seven million horse-power has so far been developed. The author describes this engineering feat, a notable achievement being the automatic power station which is worked entirely by a single operator miles away.

THE Dominion of Canada has a land area of 3,600,000 square miles, or about seventy times that of England. It is a land of great lakes and rivers; Lake Superior has an area of 31,800 square miles, while eight rivers are more than a thousand miles in length. A tremendous volume of water is continually flowing down from the heights of land, finding its way into the Atlantic, Pacific, and Arctic Oceans; and when it is considered that eleven cubic feet of water falling one foot in a second can be made to generate one electrical horse-power, it is not surprising that Canada is one of the great water-power countries of the world.

Winter in the greater part of the country is very severe; most of the precipitation is then in the form of snow which does not find its way into the rivers until the spring. The seasonal variations in flow are therefore very great, and in order to ensure a power supply which is a mean of these variations it is often necessary to construct great storage systems. In some cases, where a river flows through a large lake, nature provides this storage; the St. Lawrence river, for example, flows from the Great Lakes and has not had a greater discharge than 318,000 cubic feet per second, nor less than 173,000, in the past seventy years. On the other hand in mountainous districts such as British Columbia the difference between maximum and minimum flow is often enormous, and dams have to be constructed to provide storage. The flow of the St. Maurice river in the Province of Quebec is regulated by the Gouin Dam, which creates a storage of 160,000,000,000 cubic feet. (The Assuan Dam, in Egypt, creates a storage of 78,000,000,000 cubic feet.)



POWER FOR VANCOUVER.

This power house and dam of the British Columbia Electric Railway Co. will ultimately be responsible for the production of 188,000 horse-power for the Vancouver district.

The work of measuring the available water-power is an arduous one, and involves the measurement of the rates of flow of all the important rivers at frequent intervals throughout the year. Conditions vary considerably from year to year, and statistics covering a long period of time are necessary if a reliable estimate of the possibilities of a certain power-site is to be obtained.

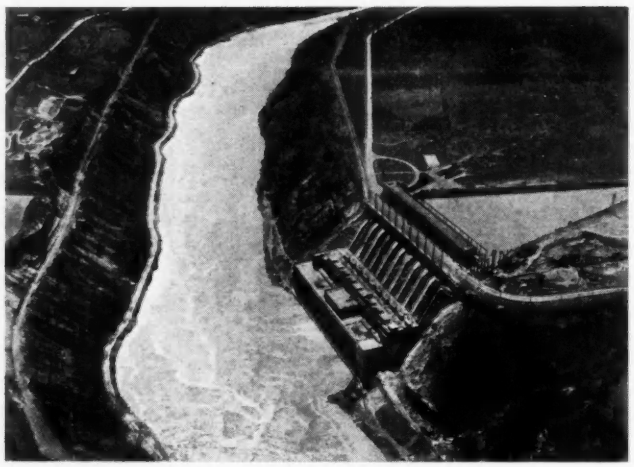
This work is carried out by the Dominion Water Power and Hydrometric Bureau of the Dominion Government, who give the size of a river in two representative figures: The first is the ordinary minimum flow. This is the average value of the rate of flow for the two lowest periods of seven consecutive days in each year, the average being taken over as many years as possible. The second figure is the ordinary six-months flow. The calculation of this figure is a little more involved, and is carried out as follows: The months of any one year are arranged in the order of the lowest-flow days in each. The lowest of the six high months in this list is taken. The average flow of the lowest seven consecutive days in this month is taken as the "ordinary six-months flow" of the year. Again this figure is averaged over as many years as possible.

From surveys already made, which do not include many rivers of gradual gradient, it is estimated that, on the basis of the ordinary minimum flow, 20,347,400 horse-power is available, while on the basis of the ordinary six-months flow the figure is 33,617,200

horse-power. The turbine installation at the present time has a horse-power some thirty per cent greater than the ordinary six-months flow figures of the streams on which they are situated, so that one may state that the *recorded* water-power resources of Canada will permit of a total turbine installation of 43,700,000 horse-power. At the present time some seven million horse-power has been developed, of which one half has been harnessed during the last nine years. The annual generation of electrical energy is in the neighbourhood of fifteen thousand million units, about twenty-five per cent greater than that of Great Britain, while the capital investment in the hydro-electric industry in Canada is estimated at more than fifteen hundred million dollars.

A hydro-electric power station involves a steady supply of water under pressure, due to the weight of the water above it: hence the importance of a fall, or "head"; a water-wheel, or turbine, which is made to revolve by the water pressing on its vanes; an electric generator, directly coupled to the turbine, which produces electrical energy in the form known as three-phase alternating current; transformers, switches, and control gear. The power available is proportional to the product of the rate of flow and the height (or "head") through which the water falls. Most of the hydro-stations in Canada have a natural head, and the chief purpose of dams is to regulate the water-flow. As these natural sites become used up, it is to be expected that dams will be used more and more to create head. An example of a power station which has no dam, both head and flow-regulation being natural, is seen in the Queenston power-house at Niagara Falls. Heads are rated as "low" (less than 100 feet), "medium" (from 100 to 800 feet), and "high" (more than 800 feet). Naturally a low head project entails a larger flow of water per horse-power than a high head, and requires a different type of hydraulic equipment. Low and medium heads are usually equipped with turbines of the propellor type, which are totally submerged in water, while for high heads wheels are used in which a jet of water of great velocity impinges on buckets arranged around their periphery. The new Beauharnois development, mentioned below, has a head of 83 feet, while one of the stations supplying Victoria, Vancouver Island, utilizes a drop of 1,145 feet. Plans for future developments in British Columbia involve heads of 3,000 feet.

The Queenston power-house at Niagara Falls is at present the largest installation in the Dominion, with a capacity of 560,000 horse-power. At this famous spot the power available is six million horse-power, of which half belongs to the United States. Canada has developed 932,000 horse-power of its share in three power stations, of which the Queenston, completed in 1924, is the most recent. There are ten generators and turbines, each generator weighing seven hundred tons. The station is several miles below Niagara Falls, the water being led to the "penstocks" (the tubes which guide the water to the turbines) by means of a concrete canal from a point above the falls. The head is 305 feet.



THE LARGEST POWER STATION.

The Queenston power station at Niagara Falls is the largest in the Dominion. It has a capacity of 560,000 horse-power, and the ten generators each weigh seven hundred tons.

Hydro-electric power must be developed at the places where it is available, which may be at some distance from the areas to be supplied. Modern generators usually have a voltage of about 13,000, this being "stepped up" by transformers to a much higher value for transmission. One of the stations supplying Toronto is at Paugan Falls on the Gatineau River, in Quebec; here 238,000 horse-power is generated and transmitted at 220,000 volts over an overhead line 230 miles long. The conductors used consist of aluminium with a steel core, the outside diameter being just over one inch. The work of surveying this line, which was first put into service in 1928, was much facilitated by aerial photography, only three hours of actual flying time being required for the purpose. In future developments it may be necessary

to transmit power over distances as great as 500 miles, and it is probably that voltages of the order of 330,000 will be used.

A recent installation is that of the Beauharnois Power Co. on the St. Lawrence river just above Montreal. This is part of a great engineering scheme whereby the river will be made navigable for ocean-going vessels from Port Arthur, on the west shore of Lake Superior, to the Atlantic, and whereby 5,000,000 horse-power will be developed, of which 1,000,000 horse-power will be the property of the U.S.A. The Beauharnois section is eighteen miles in length and stretches from Lake St. Francis to Lake St. Louis. The river has been by-passed by a navigable canal 27 feet deep, with a minimum width at the bottom of the trench of 200 yards. The power available in the section amounts to 2,000,000 horse-power, of which 500,000 horse-power will be the initial development in the power-house at the Lake St. Louis end of the canal. The generators are the largest in Canada, being forty feet in diameter and twenty-six feet in height.

THE WAPTA FALLS.

A tremendous volume of water is continually flowing from the heights of land, and eight rivers are more than a thousand miles in length.

A fascinating achievement of modern engineering is the automatic hydro-electric power station. Such a station has no attendant and is started up either by an operator in some other station miles away, or automatically when its help is needed by other stations. In British Columbia there is a fully automatic station having a single unit of 12,500 horse-power, with a head of 125 feet. On the starting signal being given by an engineer ten miles away, the main water valve opens very slowly and admits water to the turbine, thus setting the generator in motion. All the factors involved in putting the station " on the line," such as starting the lubrication and speed-governor pumps, closing of all the necessary electrical circuits, and adjustment of the generated voltage, follow quite automatically in orderly sequence. The station is shut down by a similar signal when its help is no longer required, and the slightest mishap in operation is immediately followed by automatic " shut-down." Automatic plants make possible the development of small power sites by reason of the economy of their operation.

The harnessing of water power has been a great stimulus to the development of Canadian industries. Efficient utilization of the power developed required a diversified load ; for example, if a station supplied power for electric lighting only, at certain times of the day the generators would be loaded to their full capacity while at other times they would be running idle. The larger a power-station is, and the greater the area that it feeds, the more diversified will be its load. In order to improve the " load-factor " of a system, power is sold in large quantities at a very cheap rate so long as it is used during " off-peak " hours, such as between midnight and 6 a.m. In this way it is possible, for example, to generate steam economically by electricity : for this purpose five thousand units are approximately the equivalent of one ton of coal. It is important to realize that, with hydro-electric stations, the costs of operation are fairly constant whether the generators are working at full capacity or whether they are running without any load at all.

The production of pulp and paper is Canada's greatest manufacturing industry, and its growth has been due to extensive forests and abundant water power. In the production of Canada's mineral wealth cheap electric power plays an important part, some half million horse-power being used in the mining industry proper, while about 200,000 horse-power are used for the electrolytic refining of metals and the production of chemicals.

Water power is undoubtedly one of the major factors in Canada's industrial development. It has encouraged the growth of the great paper and mining industries, and has raised the standard of living of the whole Dominion. With such an asset the country looks forward with confidence to the future.

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The Excavation of Minturnæ.

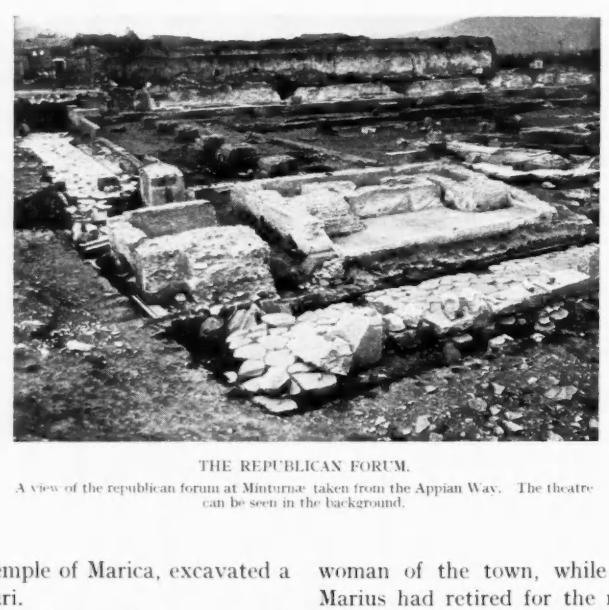
By Jotham Johnson.

Director of Excavations for the University Museum of Philadelphia.

Recent excavations at Minturnae have thrown valuable new light on the first Roman colony there in the third century B.C. Unlike many ancient cities in Italy, the site of Minturnae is not occupied by a modern town, and extensive excavations may therefore be expected. The discoveries of the first season are described by the author.

WHEN the University Museum of Philadelphia was invited by the International Mediterranean Research Association to conduct excavations in Italy, it was planned at first to dig at Stabia. But matters were later discussed on the spot with Professor Amedeo Maiuri, Superintendent of Antiquities for the Province of Campania, and Count David Costantini, President of the International Association, and it became apparent that Minturnæ offered many practical advantages over Stabia.

On the site of Minturnæ several of the ancient buildings could be identified and to some degree studied before the work of excavation was begun. Of these the aqueduct is probably the most famous. The aqueduct ended at a gate of the city, through which once passed the Appian Way. This gate had been excavated by a local land-holder incompletely, but sufficiently to date its construction, and with it a period of the city's expansion, to the middle of the first century B.C.—evidence in itself almost adequate to confirm Frontinus' statement regarding a Caesarean colony. Near the gate stands a low, oval hill long since recognized as the amphitheatre. A quarter of a mile to the east, near the bank of the Liris, the theatre rises from a low mound of debris, and near it could be traced building foundations, overgrown with brush and weeds in the middle of fields otherwise under intense cultivation. At the river-bank could be seen remains of several ancient bridges, and long rows of shipways; and finally, a mile downstream and near the river mouth, is the Temple of Marica, excavated a few years ago by Dr. Maiuri.



THE REPUBLICAN FORUM.

A view of the republican forum at Minturnæ taken from the Appian Way. The theatre can be seen in the background.

In 88 B.C. Sulla was ordered to yield the command of the army to Marius. His reply was to march on Rome, and Marius, unable effectively to meet him, was forced to flee. Setting sail from Ostia, bad weather forced him and his companions ashore near Circe's Island, where they spent a forlorn night. Wandering aimlessly by the coast next day, they were set upon by a troop of horse. By chance two boats were sailing by, and the fugitives succeeded in swimming out to them. The horsemen called to the sailors of the ship which Marius had reached to give him up, but after some hesitation they refused and sailed off with him. Marius' companions, in the other boat, landed safely at Aenaria, a nearby island.

When the ship carrying Marius reached the mouth of the Liris, just below Minturnæ, the rising wind made it advisable to seek shelter in the channel, but as soon as Marius had gone on shore the sailors pushed off again and forsook him. Marius, now desperate, sought sanctuary with an old man who worked in the marshes. The man concealed him in a cave by the water's edge; but when the noise of the pursuit came near, Marius, afraid that the old man would expose him, stripped off his clothes and plunged into the river in the hope of greater safety among the reeds. But he was discovered and his captors conducted him to Minturnæ for execution; for Sulla had sent orders through all these towns that he should be searched for rigorously, and put to death if found. The magistrates of Minturnæ, unwilling to act hastily, sent him under guard to the house of a woman of the town, while they deliberated. After Marius had retired for the night, they sent a soldier to kill him, but, according to the historian, the man

was terrified by Marius' glowing eyes, and by his solemn voice saying " Do *you* dare kill Marius ? "

At this the assassin returned to the magistrates, who now decided that the courageous part was to contribute to Marius' relief, and escorted him to the seashore again. But here they met with delay, for in their path lay the sacred grove of Marica, from which nothing which had ever entered it might be removed. Thus Marius' baggage might not pass through and the way around was long and tedious. One of his escort declared, however, that no grove was sacred enough to hold back Marius, and taking the risk on his own head, marched calmly through the sanctuary. Reaching the shore, Marius escaped to join his friends at Aenaria, whence they travelled to Africa. Plutarch further tells that Marius afterwards gave a painting of the scene to the Temple of Marica.

THE EAST ENTRANCE TO THE THEATRE.
The street leading to the east entrance of the theatre, which belongs in date either to the closing years of Augustus' reign or to the opening years of Tiberius'.

Shorter but more important references to Minturnæ are provided by Livy, who relates that in 314 B.C. the three chief cities of the Aurunci, Ausona, Minturnæ and Vescia, repudiated Rome's influence and were taken by storm. Minturnæ seems to have returned readily to the fold, for two years later the Appian Way was peacefully surveyed through the city, while Ausona and Vescia disappeared so completely that even their sites are uncertain. The next reference in Livy is to a Roman colony, for which enlistments were taken in 296 B.C. According to Velleius Paterculus, however, the colony at Minturnæ was formed in 295 B.C., " in the consulate of Quintus Fabius for the fifth time and that of Decius Mus for the fourth time."

From Frontinus we learn that a second colony was sent to Minturnæ by Caesar. Hyginus Gromaticus, with whose manuscript is a priceless sketch of the city, says that a colony was established there by Augustus. It has been suggested that both authors refer to the same colony, but it is hardly to be doubted that a colony was established by Caesar and there is good reason to accept that of Augustus also, though more convincing proof will be sought in a future campaign.

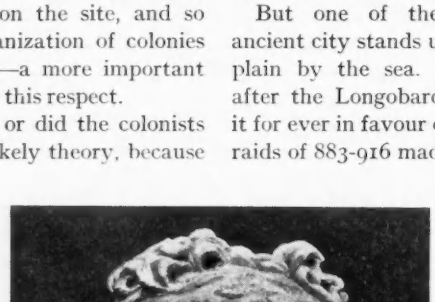
There are other useful passages in the ancient authors. Pliny and Strabo agree that Minturnæ stood on both sides of the Liris. Cato speaks favourably of the iron to be purchased there. The Peutinger Table shows the Appian Way running past Formia through Minturnæ to Sinuessa and the south, while another road, starting at Minturnæ, leads to Teano, presumably by way of Suessa Aurunca and the same mountain pass that the modern Via Appia follows.

Thus considerable information about Minturnæ was to be had without recourse to the spade. In the opinion of several colleagues with whom the prospect of excavating the city was discussed, further information, whether on Minturnæ or on Roman archaeology and history, was superfluous in view of the tremendous mass of Roman material already available. No Italian site would prove as instructive as a corresponding site of Greece, Asia Minor, Syria, etc. Furthermore, in 1819, Minturnæ had been excavated, apparently with great thoroughness, by Nugent, an Austrian general in the service of the Bourbon Kingdom of Naples. The large number of statues and architectural fragments carried off by Nugent, and now in the museum of Zagreb (Jugoslavia), would indicate that little more awaited the excavator's spade in Minturnæ. Why, then, conduct further excavations ?

From the vantage-point of eleven months of work at the site, we can take vigorous exception to these observations. Deferring momentarily the question of finds in favour of the monuments, we must realize that in the light of the new discoveries at Minturnæ we have much to learn about early Rome. Rome itself can tell us relatively little about Roman ideas in city-planning ; first, because in spite of the extensive and remarkably fruitful modern excavations in some parts of the city, relatively little of the whole will appear in this century ; and second, because the heart of the city and the trail which led into it—to condition the city's growth for ever after—were crystallized at a period earlier than the concept of organized topography. It is true that thanks to Dr. Calza's

masterly work at Ostia we can follow *in toto* the principal elements of an early colony; *cardo* and *decumanus* dividing the rectangular space within the fortifications into four regular blocks, and internal and external pomerial streets. But the colonists of Ostia found no previous village on the site, and so Ostia tells us nothing of the organization of colonies sent to towns already flourishing—a more important group, for Ostia is almost unique in this respect.

Was a separate city unit built, or did the colonists settle within the old walls (an unlikely theory, because the city walls would probably enclose an area already too small for the local needs)? Or was the earlier town enlarged to form a Dipolis? And in any case, was the basic plan modified for this special circumstance? Again, except for the walls and streets, Ostia reveals neither public constructions nor private houses. What sort of public buildings did the Romans build in the third century B.C., and what architectural school did they follow? Further, some colonies seem to have been purely military; the number of colonists is sometimes cited as 300, clearly allowing only for soldiers. But when the number is 4,000 or 6,000, the families of the soldiers must have accompanied them, as well as numerous artisans. To distinguish between these two economic situations is another work that remains to be done.



HEAD OF VENUS.
Among several marble sculptures found during the first season's work at Minturnæ was this head of Venus.

In other words, few ancient towns in Italy have been extensively excavated. Ostia, Marzabotto and Pompeii, and portions of Rome, are indeed consolidated sufficiently to be intensely instructive, and much may be expected of Ardea and other sites, but each type of city forms a separate field. One thoroughly excavated city will tell a story that a score of fortifications and a hundred isolated temples cannot rival, but nowhere yet can we read on the ground the story of republican Rome. The fault for this lies not with the archaeologists of Italy, but with the geographical circumstances. The reasons which first dictated the choice of town sites—almost invariably on narrow hilltops—were principally malaria and the danger of hostile raids. These conditions also dictated the site of the mediaeval successors of Roman cities to such an extent that with rare exceptions every ancient acropolis is occupied by a modern town, and for financial reasons is inaccessible to the spade.

But one of the exceptions is Minturnæ. The ancient city stands upon a low mound in a flat malarial plain by the sea. The inhabitants who stayed on after the Longobard invasion of 590 A.D. abandoned it for ever in favour of the nearest hill when the Saracen raids of 883-916 made existence in the plain precarious. Of modern constructions on the site there are only a few rooms under the arcades of the theatre—in supporting the vaults they have preserved the only traces of the external superstructure—and a large post-house, built at the end of the eighteenth century. The latter with modest alterations will fill the need for storerooms and offices when the present headquarters in the theatre are torn out, and later will become the Minturnæ Museum.

Work was begun on the south front of a rectangular temple *podium* in front of the scene-building of the theatre, at which point the cement core of the foundation showed traces of an original flight of steps. Late in the afternoon of the first day the ground course was reached; the first stone to come to light bore a twelve-line Republican inscription. Just as work for the day was about to finish the paving of the Appian Way was reached—though it was many weeks before its identification could be regarded as certain. The temple was eventually shown to belong to the period of Tiberius; in its base course were not one but twenty-nine inscriptions relating to *magistri* and *magistrae* of four cults of the second and first centuries B.C. Their successive discoveries more than cover the entire campaign, as the last six were only found some days after the work had ceased, when at Dr. M. Rostovtzeff's instigation we examined the under surfaces of the stones.

Immediately to the west of this temple lay the foundations of an Italiote temple of the third century B.C. When the excavation of this *insula* was completed,

the temples proved to be in the middle of the open area enclosed by the three wings of a large *stoa* whose façades gave on to the Appian Way. In several reconstructions it had survived until the late period of the city, but its first building was shown to belong to the arriving Roman colony of 295 B.C. Thus the first campaign has completely cleared the republican Forum of the city, consisting originally of the *stoa* and a temple, and a larger free area.

Trenches in the corresponding *insula* across the Appian Way proved that there lay the Imperial Forum. At several points the ancient paving is only a few inches below the modern level, and except for the east side, which was occupied by a long single colonnade, systematic excavation in the Imperial Forum was deferred until a later season. One promising aspect of future work in this *insula* was provided by a hole sunk in the floor of the colonnade, which revealed foundations of private houses, almost certainly belonging to the first colony, and sealed in by the solid floors of later constructions.

HEAD OF DIONYSUS?
Another discovery of interest, which is thought by the excavators to be a head of Dionysus.

To the east of the fora, opposite each other on the Appian Way and so corresponding with the fora themselves, are two temple sanctuaries. It was possible to excavate one of these almost entirely. It consisted of a high *enceinte* wall about the whole area, a three-winged colonnade, and, in the middle, the temple. The first period of this complex goes back to approximately the time of Caesar. The sanctuary opposite could not be undertaken during this campaign, but its *enceinte* wall can be followed in its entire length on the surface of the ground. It seems likely that in this *enceinte* the temple was built at the extreme rear of the enclosure rather than in the centre. Further to the east lay the low acropolis of the Auruncian city of Minturnæ. By good fortune a minimum number of trial trenches disclosed a portion of each of the four walls, establishing its entire perimeter. It belongs to a period of polygonal construction which in spite of the accumulated studies of many scholars cannot yet be dated satisfactorily; it is tentatively assigned to the early fifth century. This city was enlarged by the addition of another rectangular area to the west, whose wall of *opus quadratum* could confidently be assigned to about 300 B.C. and so must belong to the Roman colony of 295. Within this area lie the *insula* of the republican Forum and the *insula* of private houses which later became the Imperial Forum. It was not possible to follow the limits of the colony wall, but this is the first task reserved for the new campaign.

The theatre, as we have seen, lies immediately to the north of the republican Forum. Of this only the east parodos was cleared, as its extent will necessitate an entire season of steady work. Some of the lowest seats were found to be *in situ*; and although many architectural fragments have vanished, it is likely that enough remain for a valuable paper reconstruction. The theatre construction is so identical with that of the aqueduct—which has been shown to belong to the closing years of Augustus' reign or the initial years of Tiberius'—that they must be contemporary.

As for the finds, their number and interest are remarkable in view of a fact that the republican Forum, the centre of excavations during the first campaign, was the scene of Nugent's excavation in 1819. Only inconsequential fragments of marble sculpture, and relatively few architectural elements, were found in the entire block. Elsewhere Minturnæ is surprisingly untouched. In the excavated temple *enceinte* a score of good pieces were found, largely within a metre of the surface, and two places proved deliberate ancient repositories of sculpture in marble: a deep water-channel which ran beside the Appian Way, and a vault which formed a temple substructure. Among these were portraits of Tiberius, Domitian and perhaps Germanicus, a number of excellent private portraits and two Venuses. An original Greek work was found, signed by Kallimachos and Gorgias of Athens; only a leg and tree-trunk were preserved. For the future it is not a question of searching for oases in a desert, but of selecting the most important centres in a long series of undeniably fertile spots.

The Progress of Medicine—IV.

The Fight Against Tropical Diseases.

By D. B. Blacklock, M.D.

Professor of Parasitology, Liverpool School of Tropical Medicine.

Malaria, sleeping sickness and yellow fever are very widespread tropical diseases; in the study of each recent advances have been outstanding. Yellow fever has lately acquired a new importance as a result of rapid modern transport which tends to spread the disease. This is among the problems discussed by the author.

MALARIA, sleeping sickness and yellow fever have certain features peculiar to each, while in other features they present some similarities. Malaria is widespread in the tropics, sleeping sickness is confined to Africa, while yellow fever is endemic in West Africa and South America. The microscope enabled Laveran in 1880 to discover and describe the plasmodium which causes malaria; it also enabled Dutton in 1902 to describe the trypanosome of sleeping sickness, but it has not enabled anyone to describe the parasite of yellow fever. Minute as are the plasmodium of malaria and the trypanoscome of sleeping sickness, the cause of yellow fever is infinitely more minute; it was shown in 1901 by Reed and his colleagues to be so small as to pass through the pores of a filter which suffices to stop the passage of even small bacteria.

Each requires an insect to transmit it from one human being to another. What the mosquitoes of the genus *Anopheles* do in malaria, is done by the tsetse-fly, *Glossina*, in sleeping sickness and by the "tiger" mosquito, *Stegomyia fasciata*, in the case of yellow fever. The case mortality from malaria is relatively low as compared with that from sleeping sickness and still lower than that which results in epidemics of yellow fever. In relation to this it may be noted that for malaria there are certain drugs, such as quinine, which have a very useful curative power, that in sleeping sickness drugs like arsenic and "Bayer 205" are relatively effective, whereas for yellow fever there is no drug which is known to have any curative action. A person is liable to frequent re-injection by the vector insect in each case, but whereas malaria and sleeping sickness may occur *de novo* in a person who has already had these diseases, this is not the case with yellow fever, of which one attack confers life-long immunity.

Many facts about malaria were understood long before the real cause of it was discovered; it was known to be a disease of marshy places, being popularly attributed to the dank air or miasma from them; it was known to be best treated by Cinchona bark, a substance introduced into Europe from South America by the Countess of Chinchon, and called after her; from it quinine was prepared.

In 1880 Laveran, a French medical officer in Algiers, discovered in the blood of a sufferer the parasite which caused the ague paroxyms. In 1897 Ross, when a British medical officer stationed in India, proved that the parasite of malaria was conveyed from the sick to the healthy by mosquitoes. He obtained these insects and allowed them to bite persons whose blood contained the malaria parasite; the mosquitoes were kept alive so that each day a number could be examined, the various parts of the body of the insect being carefully dissected; a search was made for any sign of development of the malaria parasites which had been taken into the mosquito's stomach in the blood it had swallowed. He was successful in finding such stages of development and proved that the parasites had penetrated into the wall of the stomach in some of the insects, and also that they had changed in appearance and grown larger (Fig. 1). He then discovered that the mosquito was utilized by the parasite as a living vehicle in which it could mature and multiply sexually, so that about a fortnight after the insect had fed on the infected man,

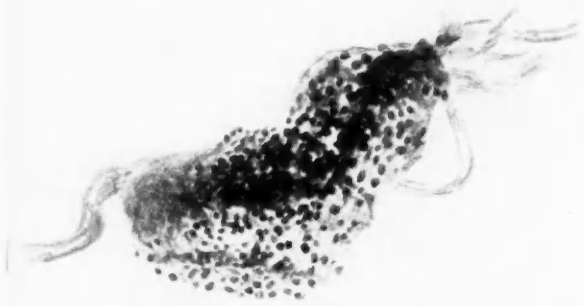


FIG. 1.
This photograph shows the way in which the malaria parasites penetrated into the wall of the stomach of some of the insects studied.

its salivary glands contained minute descendants of the original parasites, in the shape of slender tapering bodies called sporozoites; these were injected into the human skin with the mosquito's salivary fluid when next it bit anyone.

It was shown, and it is still accepted to-day, that there was only one genus of mosquitoes, the genus *Anopheles*, of which the species are capable of acting as transmitters of human malaria; further, accepting the sporozoite rate as evidence, it was proved that not all the species are equally dangerous as carriers in nature. This knowledge has hitherto been useful in the following way: a doctor on going to a malarious district could quickly reveal which species of the local anopheline mosquitoes were the most dangerous, by collecting the insects from native or European houses, dissecting them and finding in their salivary glands the minute infective sporozoites. Having thus ascertained which anopheles mosquito was the chief carrier he could devote his main energies to preventing this particular anopheline from multiplying; this he could accomplish by draining away, oiling or chemically treating the accumulations of water in which the insect's eggs are laid and in which its larvae and pupae pass their existence; he could also apply biological methods of control.

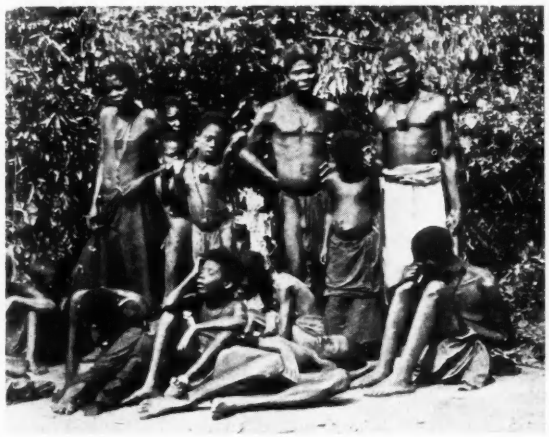


FIG. 2.

Natives infected with sleeping sickness. Treatment with organic compounds of arsenic has been found to have remarkable effects.

Not a few people have suggested that man might become infected with malaria from animals such as various apes and monkeys, many of which have similar malaria parasites. Since, however, it had never been proved that such animal-to-man infection did occur, it was assumed that, if any anopheline mosquito caught was found to contain in its salivary glands the infective sporozoites, then it must be a carrier of human malaria.

This comforting belief has quite recently been shown to be open to doubt; Green, who is working in the Malay States, has proved experimentally that anophelines may become infected with the malaria of a common eastern monkey, *Macaca irus*, and he finds it impossible to decide, by dissecting such a mosquito, that it is a monkey parasite and not a human malaria parasite which it contains. Further, he has shown that one anopheles mosquito which has hitherto been recognized (largely on account of dissections) as a most important carrier of human malaria in Malay, can also become infected with this monkey parasite. The bearing of these results is clear, and it is evident that strict reliance cannot now be placed on dissection of wild anophelines for evidence of their capacity to infect man with malaria; the sporozoites found in them may be those of monkeys; and what applies in the Malay region may well apply elsewhere.

It is remarkable that, very soon after the publication of the Malay results, it was recorded from India by Knowles and Gupta that they had succeeded in inoculating three volunteers with malaria parasites from an African monkey, *Cercopithecus pygerythrus*, imported from Singapore; the parasites proved peculiarly fatal on inoculation into *Macacus rhesus*, an eastern monkey. These highly important observations make it evident that our views on the significance of infection found in naturally infected anopheline mosquitoes will require considerable readjustment, not only as regards the eastern region, but also the African and probably the entire tropical and sub-tropical world. They also suggest that the possibility of man becoming infected with malaria from monkeys by means of such mosquitoes must now be reinvestigated afresh.

Primarily the treatment of malaria is undertaken to relieve and cure the sufferer so as to prevent relapse, and recently efforts have been directed to finding drugs which will do this with greater certainty and convenience, and at less expense than quinine. Secondarily, however, there is another effect to be considered in treating persons suffering from this disease. The fact has long been known that those stages of the parasite which are capable of giving rise to infection in mosquitoes are not easily destroyed in the blood of man by quinine treatment, although the patient may be cured of his acute symptoms. Therefore research has been directed towards discovering or manufacturing drugs which will dispose

of these stages which can infect mosquitoes. Further, since it has been proved that a healthy person who is taking the usual small doses of quinine may nevertheless become infected with malaria if an infective mosquito bites him, efforts are constantly being made to discover some safe drug which a healthy person can take regularly, and which will have the effect of killing any sporozoites which the infective mosquito injects into his skin with its salivary fluid while biting him.

Drug Administration.

There are thus three somewhat different aspects of drug administration in malaria districts. First of all there is administration to relieve the patient's symptoms and prevent him from having a relapse; secondly there is that designed to eradicate from his blood those stages of the parasite which, while they do not inconvenience the patient, are nevertheless capable of infecting an anopheline mosquito if it bites him; finally there is the administration, to healthy persons who are exposed to infection, of drugs which will kill any sporozoites which an infective mosquito may inject into their systems; this third aspect is that of prevention of infection or prophylaxis.

In connexion with the cure of the disease and prevention of relapse two recent drugs require mention here. The first is plasmoquine which was produced in Germany during the War largely to compensate for quinine shortage. Schulemann states that this drug, used in combination with quinine, cures the disease and reduces the relapses in simple tertian malaria, from the usual figure of fifty per cent to three per cent; in another form, quartan, no cases treated suffered from relapse; in the third form of malaria, malignant tertian, plasmoquine does not prevent relapse. The other drug is atebrin, made by the chemists Mietzsch and Mauss; this is a still newer preparation and in some experiments it has been more successful than quinine in curing and preventing relapses. Thus James had only one case of relapse in fifteen persons treated by atebrin, and Green, who also tested it, records no relapse in nineteen cases.

Plasmoquine has further possibilities than mere efficacy in treatment, possessing the peculiar power of destroying in the blood of man those stages of the malaria parasites which can infect the mosquito. It has been administered on a small experimental scale in malaria districts with this end in view. Kingsbury and Amies tested its effects in a rubber estate in Malaya; they gave the drug regularly to 330 people and observed the results during a year. The sickness rate of the estate fell by fifty-one per cent, whereas on two estates where the drug was not administered the sickness rate fell by only eleven per cent in the one, while it rose by twenty-one per cent in the other. Barber, Rice and Brown in Liberia also record the effects of giving it to persons in a heavily infected area. After a suitable period of administration to the people they dissected 1,478 anophelines without finding one infective, whereas before the experiment four out of every hundred anophelines captured were found infective. When the drug was stopped for a fortnight, the anophelines showed a rapid return of infection. As regards atebrin, it has been shown by the work of Strickland and Roy, and that of Green, that it has not the same power as plasmoquine to prevent mosquitoes becoming infected from man.

Plasmoquine has still further importance because it has been shown that healthy persons who are taking it in sufficient doses do not become infected even when infective anophelines bite them; it destroys the parasites soon after the mosquito has injected them. James, Nicol and Shute made experiments which proved this prophylactic power; their observations were tested by Schwellengrebel and de Buck; these observers did not find that the volunteers were protected. They used, however, only half the dose, because they considered the doses used by James to be too large for safe use in practical work in malaria districts. To sum up this section it has been suggested that an ideal treatment would be to combine atebrin, which cures the case and prevents relapse, with plasmoquine which destroys the stages which infect the mosquito. Further experiments, especially as regards prevention of the infection of man by mosquitoes through the use of plasmoquine or similar drugs may, it is hoped, lead to a solution of this problem of prophylaxis.

Sleeping Sickness.

The trypanosome of sleeping sickness is found in the blood and at later stages of the disease, even when sleepiness has not yet begun, it can often be found in the fluid of the spinal canal. In 1909 Kleine showed that these trypanosomes were transmitted from an infected to an uninfected animal by the tsetse fly, at an interval of about twenty days after it had fed on the blood of the infected animal. The treatment of trypanosome infections with organic compounds of arsenic was first tried by Thomas who used atoxyl with remarkable effects, much superior to those obtained by the use of other drugs. In passing it should be observed that it was as a result of the introduction of atoxyl by Thomas of Liverpool that Ehrlich and the German chemists were guided to the lines of research which resulted in the

discovery of salvarsan and many similar drugs since evolved.

Relatively successful as have been the results of arsenical treatment in sleeping sickness, there are several factors which have interfered. The first is that if too large doses are given, the patient may suffer from blindness, even though cured of the disease; the second is that if too small doses are given, the trypanosomes are not all killed, and if such treatment is persisted in, those trypanosomes which survive acquire a resistance to the lethal effects of the drug. Thus the patient cannot be cured by repetition or even increase of the doses of the drug, though the fly can still infect itself from such a person. It may be a serious matter in endemic and epidemic regions if this arsenic resistant type of trypanosome can be passed on through the fly and infect a new person and still retain its acquired character of arsenic resistance. For this reason it would be satisfactory if we could say that there was no such danger, and that passage through the fly brought the trypanosome back to a normal state of susceptibility to the drug; unfortunately this is not the case.

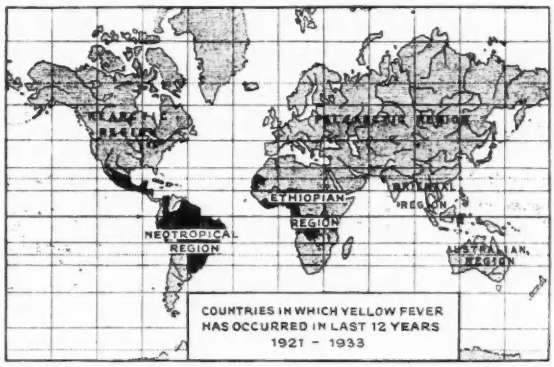


FIG. 3.
A sketch map showing the countries in which yellow fever has occurred in recent years.

It has quite recently been proved that trypanosomes which are made arsenic-resistant carry this character with them through the course of development in the tsetse fly, and the trypanosomes which the fly injects into the next animal it bites are still resistant to arsenic, so that the infection is not curable by even the largest doses of arsenic which the animal can survive. Yorke, Murgatroyd and Hawking, who have done these experiments, point out the dangers which may follow from the customary wholesale administration of atoxyl to natives in sleeping sickness areas of Central Africa.

The establishment of drug-resistant trypanosome races in the endemic areas of sleeping sickness appears then quite a possible contingency, and this consideration will serve to concentrate attention on the necessity of making further efforts to reduce the tsetse by more extended and concerted action. In this connexion such experimental work as that done in Sierra Leone against *Glossina palpalis*, a tsetse which lives near water, should be completed. There, over a limited area, the bush breeding places of the fly were cleared, and a perennial grass, Melinis, was planted; this is a fodder grass and has proved capable of holding its own against the wild grasses. Should it prove that tsetse cannot breed in it, then the planting of this grass in cleared areas would provide means of grazing cattle and so would make tsetse-cleared ground of great economic value to the natives.

Yellow fever has always been a dreaded malady; the method of transmission of the disease was established in 1900 by the American Commission consisting of Reed, Carroll, Agramonte and Lazear. Carroll allowed himself to be bitten by a mosquito, *Stegomyia fasciata*, that had fed on a yellow fever patient twelve days before. He developed a severe attack but recovered; later Lazear was accidentally bitten by an infected mosquito and died.

The more recent discoveries are that the monkey, *Macacus rhesus*, is readily infectable experimentally with yellow fever and dies from it. This fact was established by Beeuwkes and his collaborators in the West African Yellow Fever Commission. A still further advance was made by Theiler, who found that mice were susceptible to the virus, and that the virus could be attenuated by passage through mice until it no longer killed *Macacus rhesus* when injected into it. The developments of this important work are significant. It is now possible to make a healthy person immune from yellow fever by the injection of this attenuated mouse virus, plus some serum of convalescent patients.

In late years yellow fever has acquired a new importance owing to recent developments in methods of transport. In fact, a great deal of alarm is being caused by statements that yellow fever may pass to the East owing to the modern rapid communications. The danger certainly exists, but there are two practical ways of combating it. One is by taking precautions to see that no cases of yellow fever or any infected mosquitoes are allowed to leave the endemic areas; the other is so to prepare the Eastern port cities that the danger of epidemics may be avoided.

Attacking the Apple Sawfly.

By Herbert W. Miles, M.Sc.

Adviser in Entomology, Victoria University of Manchester.

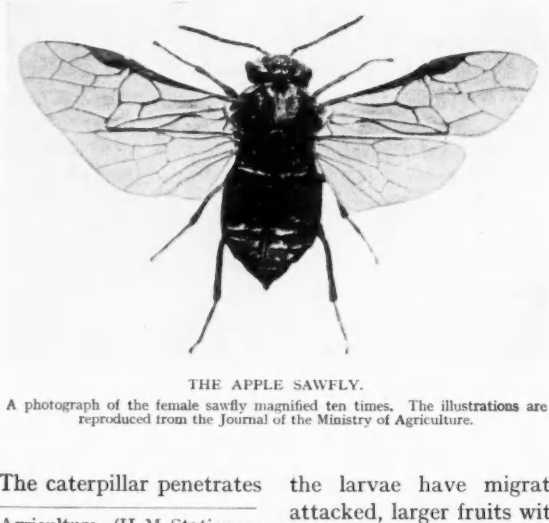
The ravages of the apple sawfly are responsible for heavy losses to growers. The author describes a new experiment in the control of the pest by which the trees are sprayed at blossoming with a naphthalene dust. This simple method of attacking the fly is likely to save thousands of pounds.*

DURING the past few years attacks by the apple sawfly have been serious. One grower estimated his loss through this insect in 1932 at not less than £1,000. The general outlines of the sawfly's life history have been known for some time, and recent research has discovered many of the details. The apple sawflies are small, brownish-red insects with two pairs of transparent wings. Towards the end of April and in early May they can be found about the apple blossoms. In bright sunshine, especially during the morning when the temperature is rising, they are very active and run about the leaves and blossoms with their head feelers vibrating rapidly. During periods of activity they can be observed feeding on drops of moisture, nectar and pollen, mating and laying eggs.

The eggs are laid in the receptacle of the blossom, that is, in the part which later develops into the fruit. They are inserted just below the calyx and lie in the tissue at the base of the petals and stamens. During the period of incubation the eggs swell and often rupture the tissue above them, so that they can be seen with the naked eye, lying wholly or partly exposed within the blossoms. Hatching takes place in from eight to fifteen days, the period being influenced by weather conditions.

When the young caterpillars emerge from the eggs they are actually outside the fruit and have to eat their way in. Some enter the fruit from within the shelter of the shrivelling petals and stamens, but most of them crawl outside the calyx and enter the fruit from the side. Usually, only one caterpillar attacks a fruit, although occasionally up to three individuals may be found. The caterpillar penetrates to the core and feeds mainly on the developing seeds or pips. After moulting twice it leaves the fruit by a hole in the side and penetrates a second and larger fruit, again from the side. It usually reaches maturity in the second fruit about six or seven weeks after the egg was laid.

Not all the newly-hatched caterpillars are successful in penetrating to the core of the fruit. Some of them tunnel just beneath the skin and as the fruit swells the skin over the tunnel breaks and a scar that the fruit carries until harvest follows the line of the tunnel. The caterpillars of the apple sawfly are whitish, and when fully grown they measure up to half an inch in length. The dark plates at the tip of the body become pale and less conspicuous, and the black head becomes yellowish-brown with only the eyes and jaws dark brown. The body is thick behind the head and tapers rather rapidly, so that the caterpillar has a somewhat humped appearance. The mature caterpillars leave the infested fruits and enter the soil. Usually they tunnel to a depth of three to nine inches and construct parchment cocoons in which they spend the winter. Pupation takes place in the spring and the adults emerge towards the end of April.

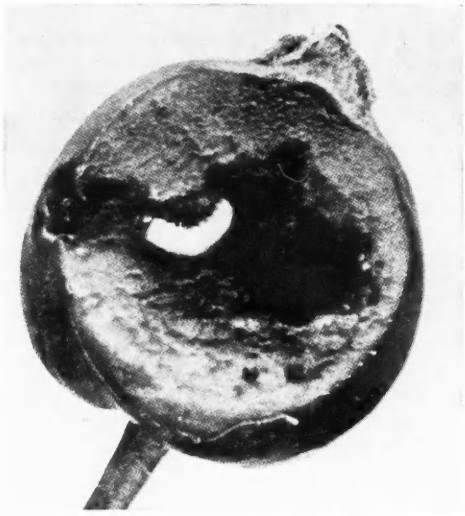


THE APPLE SAWFLY.
A photograph of the female sawfly magnified ten times. The illustrations are reproduced from the Journal of the Ministry of Agriculture.

Attack by apple sawfly can be readily recognized in the fruit plantation. It is associated with an excessive fall of newly-set fruit. In an infested plantation, the fallen fruits have holes in the side from which quantities of brownish "frass" protrude. If these fruits are cut open the middle is seen to be a wet, decaying blackish or brownish mass, and whitish caterpillars may be found within. After the larvae have migrated from the fruitlets first attacked, larger fruits with holes in their sides may be seen hanging on the trees. Where an attack is in

* The Journal of the Ministry of Agriculture. (H. M. Stationery Office, 6d.).

progress, the strong and rather offensive odour of the caterpillars is usually noticeable and workers in the plantations are quick to detect it. Treatment with lead arsenate and nicotine sprays is, perhaps, the most effective method of control. Recent work at Cambridge and by the Long Ashton Horticultural Research Station has given further information on the value of nicotine and indicated the importance of the accurate timing of the spray to catch the hatching and migrating larvae.



AN INFESTED APPLE.
The apple has been cut open to show the black excavated interior and the sawfly caterpillar present

Observations by the writer showed that female sawflies were present in a plantation of mixed varieties for about a fortnight, and this suggested that there might be considerable difficulty in timing a nicotine spray to catch larvae hatching and migrating over a similar period. In practice, the critical time depends on the flowering period of the variety, and it would be necessary to arrange spraying to suit the varieties. With mixed varieties this is difficult, and it seemed desirable to experiment with other methods of control.

In 1932 arrangements were made at the Cheshire School of Agriculture to test the value of a repellent that might either drive away the egg-laying females or render the fruit blossom unattractive to them. Naphthalene, a well-known repellent, was selected and a dust containing about thirty per cent of pure naphthalene was obtained. The variety "Worcester Pearmain" was selected for the tests because it appeared very susceptible to sawfly attack. The trees available were apportioned out to give blocks of three trees, alternating treated and untreated plots. The trees were bush type averaging eight to nine feet high and with a branch extension of about six feet.

The first application of dust was made on 24th May, when ten to twenty per cent of the blossom was open; and further applications were made on 28th May, 3rd June and 6th June. On the final date, only the last ten to twenty per cent of the blossoms remained open. The dust was used at the rate of three pounds for twenty trees at each application. It was exceedingly light and adhered well to the foliage and blossoms, and the smell of the naphthalene was evident for several days after the applications, especially during the warm sunny periods when the sawflies were most active. About a fortnight after the last application, when it was seen that larvae had hatched and penetrated the young fruits, both treated and untreated trees were examined and the infestation recorded from the centre tree in each block of three. The set of fruit varied considerably from tree to tree, as is usual in young plantations, but there were no indications that the dust had adversely affected fruit setting.

In the first count, it was found that while over twelve per cent of the fruit examined from the untreated plots was infested with sawfly larvae, less than two per cent were infested on the trees that had been dusted with naphthalene. The second examination was made when the attack had reached its height and no further fruits were likely to be infested. The effect of the treatment was still evident, since about twenty-five per cent of the fruit from the untreated trees was attacked and only seven per cent was attacked on the dusted trees. It is probable that the value of the dusting was greater than the figures indicate. The odour of the dust permeated through the whole section of the fruit plantation and this seemed to reduce infestation on the untreated check trees. This assumption was justified by the observation that other varieties of fruit trees at a greater distance from the dusted trees showed thirty to forty per cent infestation.

Thus it is clear that attack by apple sawfly can be reduced by dusting the trees at blossoming with a naphthalene dust. In these trials, the dust appeared to reduce attack and at the same time did not interfere with the setting of the fruit. Dusting is a fairly rapid operation and an extensive plantation can be dusted in a comparatively short time. If growers wish to give the treatment a further test, several light dressings should be applied, because the blossoming period lasts several days for each variety, and in the dust form naphthalene is in such a fine state of division that it volatilizes quickly.

Africa and Early Man.

A conference to discuss the remains of early man recently discovered by Dr. L. S. B. Leakey in East Africa was held at Cambridge last month. The following extracts are from "The Times" report.

THE conference at Cambridge, which was convened by the Royal Anthropological Institute and presided over by Sir Arthur Smith Woodward, F.R.S., described Dr. Leakey's discoveries as of exceptional importance and urged the early organization of another expedition with similar aims.

The geological committee, after considering the character of the deposit at Kanjera, do not believe that the fragments discovered there can have been introduced into the calcareous deposit at a later date. They feel clear that the two fragments said to be *in situ* belong, in fact, to the original deposit. Also those members of the committee who have seen the deposits in question support Dr. Leakey in his view that the Kanam and Kanjera deposits antedate a period of great local tilting and faulting and of volcanic activity.

The committee on palaeontology report that Kanam East and Kanam West exhibit differences only in the relative number of the fossils of different groups. With the human jaw at Kanam West were found close relations of the two types of rhinoceros still living in the region, a small hippopotamus, a pig, an antelope, fragments of two mastodon teeth of a very large deinotherium, and remains of trionyx. In Kanam East the collection consists chiefly of mastodon with a primitive elephant, and a few specimens of hippopotamus, rhinoceros, antelopes, horse, and a young monkey, but no deinotherium.

The committee think that the Kanam deposit should be referred to the Lower Pleistocene, in which the dinotherium and mastodon are survivals from the Upper Pliocene. They also think that the Kanjera fauna cannot be later than the Middle Pleistocene.

Great Antiquity.

In a necessarily technical report, the anatomical committee reports that the specimen known as "Kanjera No. 3" exhibits a condition consistent with great antiquity. The sub-committee agree to the correctness of associating all the fragments in question. In the specimens submitted to them the committee have observed no characters inconsistent with the reference to the type of *Homo Sapiens*. The absence of a frontal torus seems to exclude "Kanjera No. 3" from association with Neanderthal types. Pending further inquiry the committee are not able to cite examples of cranial vaults of the thickness characterizing "Kanjera No. 3" in non-pathological examples of the modern types of *Homo Sapiens*, but they note the occurrence in Piltdown (Eoanthropus) and the Boskop calvaria. The committee have noted the presence of a transverse occipital suture, which is rare in modern crania. The committee have observed no detail in the fragments of femur inconsistent with its inclusion in the type of *Homo Sapiens*.

Reconstructing Fragments.

The specimen known as "Kanjera No. 1" has been reconstructed by Dr. Leakey and Mr. McInnes from numerous fragments. The sub-committee accept their association, but are not able to exclude the possibility of some distortion of the actual specimen being manifested in the reconstruction. The committee see no reason to distinguish between "Kanjera No. 1" and "No. 3," either in regard to the degree of mineralization or in regard to antiquity. It is noted that Dr. Leakey's reconstruction and his placing of the two main pieces of the specimen provides a maximum length of 200 mm., and that the mid-sagittal contour is strongly suggestive of that which has been accepted by them as reasonably representative of "Kanjera No. 3."

The committee remark that "Kanjera No. 1" does not possess the great thickness seen in "Kanjera No. 3," also that the transverse diameters seem to be less in "No. 1" than in "No. 3." On the whole survey the committee are prepared to associate "Kanjera Nos. 1 and 3" as possibly representatives of the Kanjera type—female (No. 1) and male (No. 3). Having examined the fragment of mandible found at Kanam, the committee agree that the appearance of true specimens is not inconsistent with the high antiquity assigned to it.

With the possible exceptions of the thickness of the symphysis, the conformation of the anterior internal surface and what seems to be a large pulp cavity of the first right molar tooth, the committee are not able to point to any detail of the specimen that is incompatible with its inclusion in the type of *Homo Sapiens*. In arriving at this conclusion the committee have had regard to the conformation of the parts about the chin. They have noted that the incisor teeth show signs of crowding. They have detected no indication of unusual size in the canine teeth.

The archaeological committee finds no reason to doubt that the series from East Africa is of at least equal antiquity with the European, and it may even begin somewhat earlier.

What is the Meaning of Eye-spots?

By Major R. W. G. Hingston.

What is the meaning of the eye-spots which occur in many reptiles and insects? The author has made a special study of this curious feature, and explains how the possession of imitation eyes is one of the many kinds of "bluff" with which the more defenceless creatures are equipped by nature.

Of all patterns of animal colour, eye-spots or ocelli are the most peculiarly impressive. They consist as a rule of a dark centre surrounded by a light-coloured ring, and as their name suggests, give the impression of a real eye. They never occur among mammals. Some birds, however, are elaborately equipped with them. The magnificent eye-spotted train of the peacock is the most splendid colour exhibition imaginable. Almost equally impressive are the ocelli on the tail of the peacock pheasant or the wing feathers of the argus. Among reptiles we have good examples in the cobra's spectacles and the blue rings on the flanks of the ocellated lizard. The tortoise, *Trionyx gangeticus*, carries them on its back. We sometimes find them on the fins and tails of fishes. Among insects they occur commonly on the wings of butterflies and moths, the bodies of caterpillars, and less often on the wing-covers of beetles, mantids, grasshoppers and hemiptera.

What do they mean? They can scarcely be anything but frightening devices, imitation eyes painted on the animal in order to intimidate its enemies. We can often see this frightening influence in operation. Take, for example, the peacock's eye-spots. Each has a heart-shaped centre of irridescent blue, around it a zone of brilliant green, then a zone of bronze, then a narrower one of brown, then a fourth of gold. These splendid markings are usually regarded as ornaments for the delight of the female when the cock struts before her. It is true that the peacock does strut before his mate, but equally true that the mate does not seem to appreciate his exhibition. What concerns us, however, is that the peacock, when facing his enemy, spreads his tail in exactly the same way and makes full display of his glowing ocelli.

The Peacock's Train.

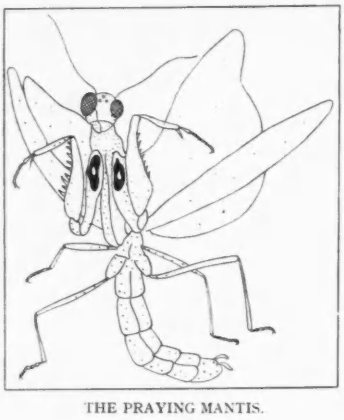
Mr. Darwin saw him thus behave before poultry and pigs. Mr. Finn observed him assume this attitude before attacking a pheasant and in order to frighten a crow. Mr. Stuart Baker writes that the display of spreading train is used "as a means of intimidation as well as of incitement to the hen bird." Dr. Lindsay mentions a cat that was frightened by a peacock. A terror-mania overcame it, involving utter loss of self possession followed by permanent timidity. The spectacle that terrified it was the spreading of the train. Peafowl, even when quite young, will try to intimidate an enemy with their tails. "It was amusing," writes Mr. Gairdner, "to watch chicks of three weeks old erecting stumpy tails and lowering wings to intimidate a young macaque or a ground lizard; or when a little older, trying to frighten a woodpecker which had excited their wrath by tapping on dry bamboo poles." Thus it is clear that the peacock's train—as apart altogether from the matter of courtship—is a psychological weapon for use against enemies. And I have little doubt that its large and brilliant eye-spots are the main element in the frightening influence which this splendid exhibition is able to bring about.

A Terrifying Spectacle.

Among reptiles the cobra best exemplifies eye-marks. I have often seen it on the plains of India expanding its remarkable hood. When disturbed, it shoots up its head like a rocket until the front part of its body stands erect. At the same time it flattens its head and neck and spreads out its so-called hood. For some minutes it holds itself in this poised attitude and sways its body backwards and forwards. It is a truly terrifying spectacle, full of menace and the possibility of awful consequences, and accentuated by the utterance of ferocious hisses and the shooting out of a dangerous looking tongue.

An important element in the display is the exhibition on the hood of two glaring eye-spots that look like a pair of spectacles. In addition the black scales separate from one another which discloses the white network between them. The result is that the uniform dark neck of the snake is not only immensely widened and flattened, but its colour is changed into a vivid pattern of black scales in a network of white. From the midst of this pattern the menacing eye-spots glare. Considering that this hood-expansion is certainly a threat, there can be little doubt that the eye-spots on it are in themselves part of the threat.

This colour mechanism of the cobra must be highly efficient, for there is another snake which copies it artificially and in a highly remarkable manner. Mr. Ridley records that *Macropisthodon rhodomelas*, a species in Borneo, erects itself when irritated and flattens out its neck after the fashion of the cobra. It



THE PRAYING MANTIS.

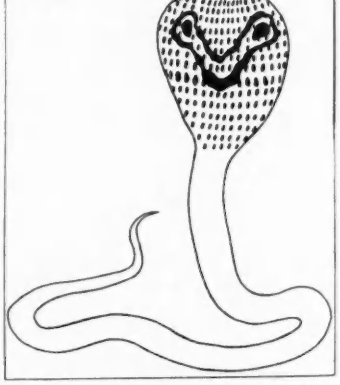
is terra-cotta in colour, but does not possess the cobra's eye-marks. On its neck, however, is a dark patch from which oozes a white viscid liquid that makes, as it were, an imitation pair of eye-marks. This liquid is very unpleasant, for when a dog seizes the snake, he foams at the mouth as though he had licked a toad. This is a truly remarkable occurrence as indicating the threatening value of eye-marks.

But it is among insects that eye-spots are best developed. In butterflies they are usually round in shape, and occur commonly near the edges of the wings or close to the wing-angles. Our peacock butterfly is a familiar illustration; and the Papilionidae, Lycaenidae and Satyrinae supply many other conspicuous examples. That they are of value to the butterfly for intimidating its enemies is shown by one of Mr. Pocock's experiments. He gave a peacock butterfly to some birds in an aviary. It settled with both wings closed. A fantailed flycatcher flew down and prepared to attack it, but the butterfly immediately opened its wings and moved them slowly up and down. This act seemed to disconcert the bird; it made no attempt to peck, but danced round the insect at a distance of about three inches. It strongly suggests that the exhibition of eye-marks had an intimidating influence on the flycatcher. A Syrian bulbul then flew down. It first inspected the butterfly, then started to peck it. But the point of interest lay in the places it pecked. The first peck was at the ocellus of the left front wing, the second at the ocellus of the right front wing, the third at the ocellus of the left hind wing which tore a bit out of it. Having done this, the bird swallowed the butterfly. This pecking out of the eye-spots is significant. What does it mean? It can only mean that the bird regarded the marks as dangerous. It pecked at them because they were the essential points from which threat was exhibited by the butterfly. One might say that the bird, before swallowing its victim, first took care to disarm it completely.

Several moths carry prominent eye-spots. A good example is the eyed hawk-moth. Its front wings are concealingly coloured, but the hind ones are rose-pink, and each has a conspicuous eye-spot composed of three rings, black, white and blue. Ordinarily the moth rests with hind wings hidden, covered over by the concealingly coloured front wings. But when the insect is disturbed, it lifts up the front wings and shows the pink hind wings with their peculiarly menacing eye-spots. This is an unusual habit in moths, and it can only mean that the exhibition of the ocelli is deliberately intended to frighten the intruder.

I have little doubt that those magnificent oriental moths—for instance, the tusser and atlas species—which may reach eight or ten inches in expanse, are protected by the threatening nature of their eye-spots. Those at the wing-apex of the atlas moth have been likened to a cobra's head. Hence we see the significance of an observation by Mr. Hannyngton on an encounter between a crow and an atlas moth. "At first it looked ten to one on the crow as the moth, a female, was apparently flying in an utterly dazed fashion. Each time, however, that the crow made a dash, the moth jerked in some extraordinary way, escaping death by inches each time. After about five futile attempts the crow got disgusted and flew into a neighbouring teak tree. The moth at once settled in full view of the crow, but to my astonishment the latter made no attempt at the sitting shot and shortly afterwards flew off leaving the moth in possession." It seems clear that there was something about the moth that checked the crow from grabbing it in the air, and later from seizing it when sitting exposed. What else can that have been if not the menacing effect of the eye-spots?

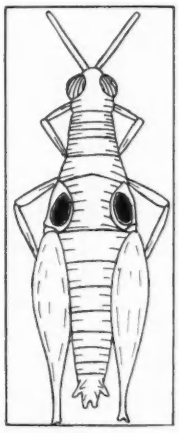
Mantids make fine exhibitions of eye-marks. The South African *Pseudocrebotra wahlbergi* has large ocellated spots on its wing-covers, and Sir Guy Marshall, who observed it in the wild state, believes that they have a frightening influence. When the insect is irritated, it raises its wing-covers so that they stand erect side by side; this manoeuvre exposes the eye-markings. An



EYE SPOTS ON THE COBRA'S HOOD.

important point about the behaviour is that the insect always turns its wing-covers in such a way as to direct the dangerous-looking eye-spots towards the object that causes its irritation.

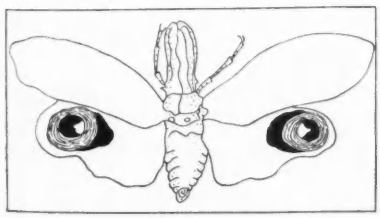
In Mesopotamia I came across one of these eye-spotted mantids, but do not know the name of the species. It lived in the open desert where there was scarcely a blade of vegetation, and when at rest blended perfectly with the sand. Its wings were stunted and of no use for ordinary purposes of flight. When I touched it, an apparition followed. The bit of sandy clay elevated itself smartly and stood erect on the tip of its abdomen. At the same time it spread out its stunted wings, and by so doing exposed on their under surfaces two large vivid eye-spots with black pupils and yellow rings. In addition the insect shook itself and gave utterance to a menacing hiss. Anyone seeing this apparition would feel confident that the eye-marks were intended to frighten.



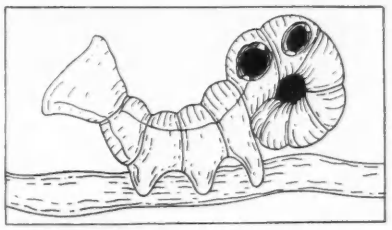
THE GRASSHOPPER.

Fabre, who distrusted all speculations on the meaning behind insect behaviour, saw instinctively the true explanation of eye-spots. He describes the attack of the preying mantis (*Mantis religiosa*). It gives a convulsive shiver and assumes a terrifying posture. Its wing-covers open and stand erect. "Planted defiantly on its four hind legs the insect holds its long bust almost upright. The murderous legs, originally folded and pressed together upon the chest, open wide forming a cross with the body and revealing the arm-pits decorated with rows of beads and a black spot with a white dot in the centre. These two faint imitations of the eyes in a peacock's tail, together with the dainty ivory beads, are warlike ornaments kept hidden at ordinary times. They are taken from the jewel-case only at the moment when we have to make ourselves brave and terrible for battle."

Among caterpillars eye-spots are very common. They occur particularly in sphingids, where the larva often keeps them hidden while at rest and exposes them blatantly when it is disturbed. Less often they occur in beetles; but I met with some examples in the Guiana forest.



THE HEMIPTERON SPREADS ITS WINGS.



HOW THE CATERPILLAR THREATENS ITS ENEMIES.

One was a cassid, *Pseudomesomphalia contubernalis*. It was a flat, broad, flake-like creature. On each of its black wing-covers was a triangular eye-mark, giving the insect a pair of yellow penetrating orbs, each with a black pupil. I feel sure they would alarm a small mammal, or lizard or insectivorous bird. Another was a weevil, *Heilipus ocellatus*. It was brown-black, oval in shape and about two-fifths of an inch long. On each wing was a conspicuous eye-mark, an oval yellow ring with a dense black velvety pupil.

It was specially striking to view this insect from behind because the end of its abdomen was so shaped as to form with the eye-marks a miniature face. There was a projection on either side with a hollow just below it which gave the impression of a pair of nostrils, and a mouth was formed by the space below the extreme ends of the wing-covers. The insect lived on the bark of trees, where its chief enemies must be the lizards that crawl about the trunks. It may be that when they come upon the weevil from behind they are frightened for a moment by the facial conformation, particularly by the glaring eyes, and this momentary consternation of the enemy gives the insect a chance of escaping. The vivid effect of these sham eyes in beetles must be seen in the living insect in order to be appreciated. After the insect is killed their colour quickly fades and their piercing character vanishes. The museum specimen gives no real impression of how penetrating they are in life.

Grasshoppers rarely carry eye-marks. But one which I met with in Guiana was interesting, because, like the Mesopotamian mantis, the spots were associated with degenerate wings. The insect, *Ommatolampis perspicillata*, was dark green and about an inch long. It had two yellow longitudinal stripes on either side of the head and thorax. Its wings were completely undeveloped, being merely triangular stumps only one-fifth of an inch long. The greater part of these stumps was occupied by conspicuous eye-marks, circular, black in colour and with narrow yellow rims.

So here again the wings have changed from flight organs into structures that have purely a menacing influence. Moreover, they must be highly efficient, for the grasshopper is exceptionally fearless and blatant. It frequents open places and sits exposed on vegetation; it allows one to bring a finger close to it, and sometimes even to touch it. One would think that it understood that the glaring eye-spots were sufficient to frighten the enemy off.

Why is it that ocelli are so peculiarly intimidating? I have little doubt that the explanation lies in the fact that they so closely simulate a real eye. When the night-haunting carnivora are enraged their eyes seem to shoot out fire. Selous states that "anyone who had not seen the fierce light that scintillates from the eyes of a wounded lion can hardly imagine its wondrous brilliancy and furious concentration." The leopard's eyes light up intensely when he snarls; those of the wild cat are said to "blaze with wrath." The puma at bay flashes green flame. The eyes of prongbucks glint with anger. Those of owls are said to shoot out sparks. Hence there can be no doubt that animals show anger in their eyes, and their eyes, therefore, must have an alarming influence. Thus anything in nature which simulates an eye will tend to arouse fear.

The Camera Lens.

It is, no doubt, for this reason that bird photographers have found that the camera lens is likely to cause more alarm in their subjects than all the rest of their impedimenta. It is said that the bittern, when it attacks, aims always at the eye, and that the American Indians, taking advantage of this habit, used to present the muzzles of their firelocks to the bird, which struck at the muzzle, supposing it to be an eye, and got its head firmly fixed in the hole. The colours of eye-spots are remarkably consistent. All through the different kinds of insects that bear them—butterflies, moths, caterpillars, grasshoppers, mantids, beetles, hemiptera—we find repeatedly the same colour combination of a black pupil with a yellow iris. This can hardly be due to chance. When insects of quite different orders and colours go in for the same type of marking and hit on the same colours arranged in the same way, there must be something special not only in the colour-arrangement, but in the particular colours used. And the explanation, I think, lies in the fact that a black pupil with a yellow iris is the common pattern of eye-colour in raptorial birds, that is, in eagles, owls, harriers, buzzards and hawks.

The exposure of imitation eyes is the most elaborate of the many kinds of bluff developed for intimidating purposes. But that it should be mere bluff ought not to surprise us. For deceit is widespread in the animal world. When we see harmless snakes erect themselves and hiss so as to give the impression that they are venomous, caterpillars for the same reason making themselves like serpents, perfectly innocent insects erecting their tails and thrusting out imaginary stings, we see that nature goes to extremes in her devices for deceit and simulation.

Chilean Insect Parasites for New Zealand.

CERTAIN weeds of the genus *Acaena* occupy extensive areas of valuable pasture land in New Zealand, while their burrs reduce the market value of sheep's wool by about £250,000 annually. Dr. D. Miller, of the Cawthorn Institute, Nelson, lately visited South America to study the influence there of the Chilean sawfly upon this weed, the foliage of which is attacked by the larvæ of this parasite.

One of the difficulties in the utilization of insects for the control of weeds is that there is a danger of the insects extending their food range to plants of economic value; to safeguard this as much as possible involves very careful study. In the case of the Chilean sawfly, however, the insect itself overcomes this difficulty in that its larvæ are active throughout the winter months when there are, with the exception of strawberry, no useful rosaceans with available foliage; and in the case of strawberry it has been found that the larvæ will not touch the foliage in the presence of *Acaena*. According to *Nature*, Dr. Miller successfully transported to New Zealand a large consignment of the pre-puæ of the Chilean sawfly packed in soil and carried in cold storage.

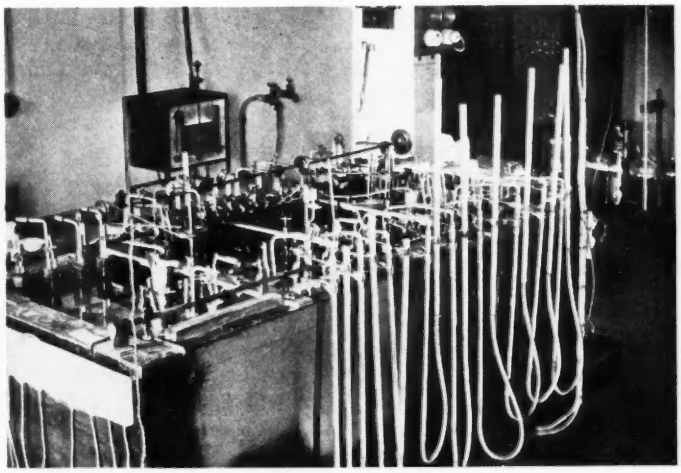
In New Zealand the insects have developed and attacked *Acaena* in a very satisfactory manner, and there is every prospect of an outstanding success in the control of the weed. When dealing with the Chilean sawfly it was found that certain species of Chilean thynnids attacked cockchafer larvæ. Just as in many parts of the northern hemisphere, the control of native cockchafers is one of the most outstanding agricultural problems in New Zealand, where the larvæ destroy great areas of pasture as well as various crops the roots of which are attacked, while the beetles, as defoliators, cause extensive destruction to turnip and rape crops. Therefore the importance to New Zealand of the Chilean thynnids was at once recognized and arrangements were made for one of the species to be dispatched to the Dominion.

New Experiments in Refrigeration.

The question of whether there is a future for the preservation of fruit and vegetables by freezing was the subject of an address to the British Association of Refrigeration. The authors described some new experiments designed to retain the full flavour and colour of frozen fruit.

THERE are, of course, three main purposes for which frozen fruits and vegetables may be used: for immediate consumption as a dessert; for cooking; for storage in bulk for catering, canning or jam-making, thus converting these into all-the-year-round rather than seasonal industries. Jams or canned goods made from frozen fruits are equal in appearance and flavour to those made from fresh fruit. This method of storage thus offers an undoubted advantage, in that there is a constant supply of raw material which, without the addition of artificial colour, can be made into an article equal to that freshly made from new material.

In a paper read to the British Association of Refrigeration, Dr. J. Barker and Mr. T. N. Morris, of the Low Temperature Research Laboratory, Cambridge, point out that preservation by freezing shares with canning the advantage over ordinary cold storage at low non-freezing temperatures that the ripening changes of the living materials are to a large extent inhibited by the canning or freezing treatments, and these treatments thus allow much longer periods of preservation than does ordinary cold storage. Moreover, canning and freezing also eliminate the risk of spoilage by moulds and bacteria which are a constant danger in cold storage. These methods usually produce well-marked changes in the quality of the products as compared with the fresh fruits and vegetables. With canning this is due to the temperature required for sterilization; with freezing, it is related to the ice-formation within the tissues. In general, however, it is safe to say that with many fruits and vegetables freezing preserves the fresh colour and flavour better than canning or any other method so far available.



A CANNING LABORATORY.

One of the laboratories at the Low Temperature Research Station, where the new experiments on the freezing of fruits and vegetables have been carried out.

The rigidity of living tissues depends, of course, largely on the distended state of the component cells, and the loss of water which occurs during the thawing of frozen material consequently results in a loss of firmness; the softening varies with the kind of fruit or vegetable. In order to preserve living material unchanged chemically, it is necessary to retard or, if possible, completely inhibit the enzymic changes. One method of retarding the changes is to reduce the temperature, and this is the basic principle of cold storage. Freezing has a still greater effect in retarding the changes than cold storage, partly because of the still greater reduction of temperature, partly because of the extreme desiccation. But although freezing inhibits many chemical changes, even temperatures as low as 0° F. do not prevent all change, and other methods of preventing chemical change have to be used in addition to freezing for certain fruits and vegetables.

There is, however, a further important effect of freezing besides its influence in reducing the rate of chemical change. Freezing also destroys the chemical organization, so that enzymic reactions take place which do not occur in the uninjured living material. The browning of frozen cherries and plums is an excellent example. How far the changes in water-holding power, in firmness, in colour, and in flavour, produced by freezing are important depends on the kind of fruit or vegetable and on the purpose for which it is to be used. With vegetables the changes of

texture produced by freezing are not of as much importance as with most of the fruits, since the texture of the vegetables would in any case be altered by cooking before consumption.

Treatment of Peas.

Peas frozen without special treatment show pronounced chemical changes in storage at 14° F. The colour becomes yellow, and disagreeable flavours and odours are produced. The changes are slower, but still quite appreciable at 0° F. Fortunately, a method of preventing these changes has been developed. The peas are partially cooked or blanched before being frozen in order to destroy the enzymes responsible for the changes of colour and flavour. Some flavour is certainly lost in the blanching and freezing treatments, but loss of flavour may be partly overcome by freezing the peas in the liquid used for blanching. Some improvement in flavour may also be obtained by using a weak sugar brine solution instead of water for blanching.

English fruits can be divided roughly into two groups, according to the effect of freezing. In the first group are raspberries, gooseberries, currants (red and black), bilberries, blackberries, sour red cherries, and rhubarb. These fruits present few difficulties, and can all be frozen and stored without special treatment, such as previous heating or addition of syrup, at a temperature of 14° F. for six months or more without serious loss of colour or flavour. Syrup can be added if desired, but it effects little improvement, if any, beyond sweetening the product. Raspberries give particularly satisfactory results in simple straightforward freezing of this kind. The texture of the thawed product is, of course, softer than in fresh raspberries, but the natural flavour and aroma are almost perfectly preserved.

The second group includes fruits which present more difficulties, and require certain special precautions for successful storage in the frozen state. These fruits are plums, sweet cherries, and strawberries, and with them simple freezing and storage at 14° F. even for relatively short periods of a few weeks or a month result in appreciable discoloration and loss of flavour; even at 0° F. this deterioration, which is no doubt due to the action of enzymes, proceeds slowly and may be appreciable after two or three months' storage. Special treatment is therefore necessary for fruits of this class.

One method which is of value in retarding enzymic changes in fruits is to place the fruit in syrup. After thawing frozen strawberries there may be a loss of 60 per cent as "drip"; this loss is much reduced by freezing and thawing in syrup. With plums and cherries, complete immersion in syrup largely prevents browning during storage in the frozen state, but browning takes place gradually during thawing even under syrup. These fruits must be cooked at once when removed from frozen storage in order to destroy the enzymes before the change has time to occur, but even when this is done, there is usually some deterioration in flavour with plums and cherries stored in this way. The only means of overcoming this is to blanch or partly cook the fruit in syrup or water before freezing, after which it can be preserved in perfect condition at 14° F. for long periods (six months or more). With strawberries the deterioration in colour is not so serious as with plums and cherries, and does not take the form of browning, but rather of a darkening and dulling of the appearance.

A good deal of work has been carried out in America to determine the best conditions for storing strawberries with sugar, and it has been shown that a good product can be obtained by freezing a mixture of fruit and sugar in the proportion of two or even three parts of fruit to one part of sugar. The only remaining method of improving the quality of frozen strawberries is by quick freezing, as in brine at —50° F., followed by storing at 0° F., or below.

The Transmutation of the Elements.

(*Concluded from page* 108)

Finally, we have recently obtained some important evidence on the interaction with matter of the high speed electrons associated with cosmic rays. The photographs of Anderson, and more recently of Blackett and Occhialini, suggest that occasionally heavy nuclei break up in a most complex manner, a typical example being shown by the Wilson Chamber photograph on Fig. 4, taken by Blackett and Occhialini. Here a shower of high speed particles is seen to radiate from a point near the expansion chamber, the density of the tracks and the curvature in a magnetic field showing that most of the particles are electrons having energies of tens of millions of volts, whilst some of the tracks are curved in the opposite direction to those of these electrons, suggesting the existence of a new type of positively charged particles of mass small compared with the proton. It is possible that this may prove to be the positive electron, the counterpart of the ordinary negative electron of light mass. This new and powerful method of attack by particles of very high energy may be expected to throw a great deal of light on that most interesting problem, the interaction of a swift electron with a nucleus.

The River Severn Barrage Scheme.

The Committee which has been engaged for seven years in investigating the possibilities of a barrage across the River Severn has just published its report. The following is a brief summary. The technical problems are discussed, and the advantages of a power plant at the barrage as compared with the normal coal-fired stations is explained.*

THREE sites have been suggested at different times for a barrage on the river Severn. A further examination has been made of the geological characteristics of each of these sites. This examination supports in every way the conclusion previously reached that, from the geological standpoint, the most suitable site for a barrage would be one situated at the English Stones on a line approximately parallel to the existing Severn tunnel.

Testing a Model.

A large scale tidal model of the Severn estuary was constructed at the Victoria University, Manchester, by Professor A. H. Gibson, who has made a special study of the construction and operation of models of this type. In a long series of experiments, begun in 1926, Professor Gibson has examined on the model the effect of various types of barrage on tidal levels and navigation in the Severn estuary. As a result Professor Gibson has been able to recommend what type of barrage would be most appropriate to the natural conditions of the estuary.

The investigations on the model have also shown that a barrage would not injuriously affect navigation *below* the barrage. Even without dredging, a barrage would not seriously affect navigation *above* it at any time of the tide, and would appreciably improve it at low water. If a comparatively small amount of dredging were undertaken, navigation above the barrage would be at least as good at high tides and very considerably better at all other times. Finally, the experiments show that a barrage would provide the means of reducing inundation of the upper estuary of the Severn in times of flood. This is an important consideration, as floods in that area are often serious, and fears have been expressed that their control would be more difficult if a barrage was constructed.

The energy that would be available from a barrage at the English Stones has been carefully estimated by Professor Gibson, who has calculated at half-hourly intervals from the mean tide curves. Independent calculations have been made by Mr. Shirley Hawkins. These were calculated at intervals of fifteen minutes, representing approximately a fall of from three to eight inches per quarter hour, according to the working head of the turbines. The two sets of calculations, each based upon a different approach to the problem, give almost identical results regarding the power that would be available. Allowance has been made in the calculations for losses due to flow over the English Stones. Certain assumptions have also been necessary with regard to the maximum output per turbine, the number of turbines that would always be available for use, the levels of the English Stones where the barrage would be situated, and the high-water level in the basin at Beachley.

There are 706 tides per annum, and it is estimated that the total output from the generators under the scheme would amount to 2,252 million units per annum. It is also estimated that some 45 million units, *i.e.*, 2 per cent. of the whole, would be required for operating the sluices and for starting up the turbine sets, operating cranes, travelling workshops, etc. There would therefore be an annual net output of 2,207 million units,available for delivery to the national system designed by the Electricity Commission for the distribution of electrical energy from selected centres now in process of being constructed by the Central Electricity Board. The consulting engineers have prepared detailed designs for the civil engineering works which would be required. They have also stated that, in their opinion, the execution of the works would cover a period of approximately fifteen years. The scheme must, of course, enable the maximum output of electricity to be generated consistent with the economic construction of the sluice and turbine dams, etc.; it must satisfy navigation requirements, including the necessary locks, guide piers, etc.; and it must provide for rail and road cross-river traffic by means of viaducts and rolling lift bridges.

Technical Problems.

The technical difficulties include the blocking of the Shoots (which is the name for the channel, approximately sixty feet in depth even at the lowest tides, which runs along the northern edge of the English Stones and in which there is at times a current as much as 12 knots); and the subsequent construction thereon of the embankment dam. The Shoots are approximately 1,200 feet wide at the point where they would have to be blocked by the embankment dam,

*Severn Barrage Committee Report: Economic Advisory Council. (H.M. Stationery Office. 6*d*.).

the overall length of which would be approximately 4,000 ft. The barrage scheme would involve the construction of works which include a tidal power station for the supply of electrical energy to the national system, a railway and road bridge, together with the necessary locks and an impounding basin above the barrage. The total cost of the barrage system would be £25,437,500, and it is estimated that the average cost of electrical energy sent out to transmission lines would be about 0.18 of a penny per unit.

Electrical Power.

The amount of electrical energy derived from the barrage would vary, depending on the tide, unless it were combined with some secondary storage scheme. Without such a scheme, it would not be possible to effect any reduction in the size and number of the coal-fired power stations included in the national system. Moreover, steam pressure would have to be maintained in the necessary number of boilers at such power stations, though it would be possible to regulate the boilers in commission to some extent during the recurring six and a half to eight-hour periods during which the barrage plant would be working. In these circumstances, no saving in wages, etc., at any of the coal-fired stations could be effected. Thus, the comparison of the cost of the intermittent supply obtainable from the barrage under such a scheme with that of an equivalent supply from a coal-fired station could only be based on the saving of coal that would be effected.

In 1930, the average weight of coal per unit generated at coal-fired stations having an annual output of over five million units amounted to 1.867 lbs. If, however, there was no secondary storage station, the supply of electricity from the barrage would vary greatly on account of the tides, both in the time of day that it would be available and in the amount generated. It would therefore not be possible at all times to utilize the supply from the barrage to deal with peak periods of demand, and to meet these it would still be necessary at coal-fired stations to provide for standby and banking losses. These in 1930 amounted to 6¼ per cent. of the total coal used. The weight of coal per unit sent to transmission lines at that date should therefore for the purposes of the present comparison be reduced to 1.75 lbs. The average cost of coal per ton in the Midlands district in that year was 11s. 4d., and the equivalent cost of coal per unit sent out, 0.1063 of a penny. In south-east England and southern districts the cost of coal was approximately 18s. per ton, and the equivalent cost per unit sent out was 0.1688 of a penny.

The practicability of the scheme from the point of view of cost depends on the question whether a secondary storage system can be installed at a cost which would enable the electricity generated by the primary tidal turbines and at the secondary station to compete successfully with that generated at the best coal-fired stations.

After consideration of various alternative sites, it appears that storage could best be provided by the construction of a high-level reservoir at Trelleck Grange, an elevated valley situated on the west bank of the river Wye, some 8½ miles north of Beachley Point where the Wye joins the Severn. The barrage plant would be able to pump water to this secondary station during the operation of the tidal turbines. The high-level water so obtained would in turn drive a set of secondary hydro-electric plant and thus provide a 24-hour supply of electricity. A reservoir on this site would have an area of about 750 acres, and would contain, between the levels of 500 and 450 feet above Ordnance Datum, 53.3 million cubic yards of water having an effective head above the power house of 440 feet. The energy stored between the levels of 500 and 450 would amount to 20,440,000 horse-power hours, and that between 450 and 400, 6,466,000 horse-power hours. Thus, the total energy stored between the levels of 400 and 500 feet above Ordnance Datum would amount to 26,910,000 horse-power hours. It is estimated that the cost of constructing a secondary power station on the river Wye would be £10,255,350.

There remains to be considered the provision which would have to be made for the increased transmission lines that would be necessary to distribute the load generated at the barrage stations to various areas. This would entail the construction of some 400 miles of double lines, the cost of which would amount to approximately £3 millions.

Facilities for Shipping.

The scheme provides additional deep water facilities which, developed by some further expenditure upon the necessary wharves and other equipment, could accommodate a large volume of modern shipping.

This is the first tidal power scheme of any magnitude to be investigated in any part of the world that has indicated a solution of the highly complex technical problems involved. In the seven years that have elapsed since its appointment, the Committee has examined all previous schemes for a Severn barrage, and considers that the present scheme merits the fullest consideration. Attention is drawn to the advantages which a power station at the barrage would possess over a comparable coal-fired power station.

The Automatic Telephone : A New System.

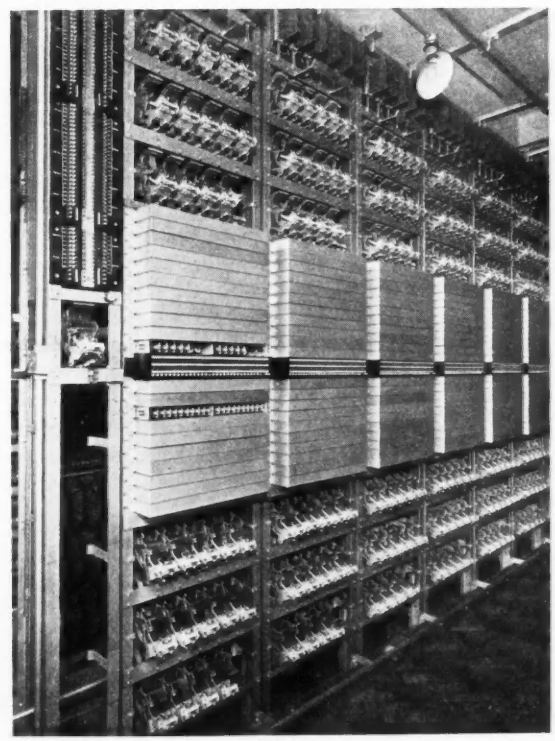
A new London telephone exchange, which has just been opened for public use, is the first in the world to incorporate the "bypath" automatic system. This is the outcome of seven years' research and simplifies the present complex process to a remarkable degree. A novel feature is the mechanism for automatically recording the volume of traffic handled.

THE installation of the new "bypath" automatic telephone system in the "Advance" exchange at Bethnal Green, London, was commenced two years ago, and during the past four months it has been subjected to exhaustive tests. The advantages possessed by the new system suggest that it will be extensively adopted in the future, for it is applicable to all types of telephone exchange, from the large city "central" to small unattended rural exchanges which are visited only for periodical inspection. The "bypath" system saves twenty per cent in the cost of apparatus, thirty per cent in the space occupied, forty per cent in weight, ten per cent in current and twenty-nine per cent in junction plant for connecting calls from one exchange to another. There is also a considerable saving in maintenance and in the number of the staff employed.

The name "bypath" was chosen for the new automatic system because the expensive switching mechanisms normally forming part of the talking circuit and kept in use throughout the conversation, are now held in bypath circuits which are only brought into operation for passing a call through the exchange. A saving of approximately fifty per cent in the amount of apparatus has thus been achieved. The new system uses only one type of switch instead of various entirely different mechanisms at present employed. The whole of the exchange equipment can be accommodated on one floor, though a second floor would have been required for automatic equipment of the old type.

The "bypath" system gives faster service on local and long distance calls, coupled with improved transmission. It also enables a call to follow an indirect route if the direct route is fully occupied. Private branch exchange facilities, enabling a subscriber to add lines as they are required, regardless of the terminal digits in the original number, are another advantage. A new and entirely automatic system of recording the amount of traffic handled has been incorporated. This records the operation of the switches on a meter similar to the subscriber's meter at present in use, enabling the Post Office engineers to see at a glance which routes are being lightly used or overloaded. They will thus be able to level out the distribution of the calls on the various routes, and so avoid complaints of congestion and delay.

Another important feature devised to deal with emergency traffic conditions has been introduced into the switch itself. It is possible by a simple operation, occupying a few seconds, to take out switches from lightly loaded lines and put them into circuits requiring emergency service, thus not only enabling the exchange to meet the requirements caused by an emergency, but also obviating the necessity of carrying large stocks of spares. The bypath equipment in the "Advance" exchange has 2,600,000 soldered connections. The exchange has a capacity of 3,400 lines, and is capable of being extended to give service to 10,000 subscribers.



"LINE-FINDER" EQUIPMENT.
A view of the bays of "line-finders" in the new London telephone exchange by means of which subscribers are automatically connected.

The essence of the new system is the fact that a minimum of equipment is held in use during the period of the conversations. As in other

automatic systems mechanical equipment is required to pilot the call through each successive stage from the dialling apparatus to the final selector. In the bypath system, the mechanism responsible for connecting a telephone conversation is not monopolized throughout the duration of the call; after placing two subscribers in contact, it becomes immediately available for the control of another conversation. A bypath connecting unit is required only to guide the conversation switches to the desired numbers; once the switches have been placed in position—the action of a few seconds—the bypath is released. Such an arrangement permits economy in the use of bypath connecting units and simplicity in design. In other systems the mechanism connecting subscribers is engaged in position throughout the conversation and is thus unavailable for other calls. This involves the provision of a large amount of apparatus to handle the traffic, in spite of the fact that much of it wastes time since it holds the connection long after it has done its work. Each bypass may be used for about ten conversational paths, and this economy in apparatus brings about a saving in the cost of equipment and a saving in bulk and weight.

A considerable advance has been made in the facilities available to subscribers with more than one line. Any subscriber in the exchange can be converted into a "multiple-line" subscriber and regular lines can be interposed in the middle of a "multiple-line" group. This means that a subscriber with several lines can extend the number of lines without the inconvenience of changing his telephone number, as was previously necessary, in spite of adjacent regular lines. This minimizes the expensive manual interception of calls which is necessary when a subscriber's number is changed. Facilities are also provided for recording the number of calls made to a particular subscriber when his line or lines are engaged.

"Storing" Numbers.

In the majority of areas where multiple-lines are in use simplicity in the numbering scheme and economy in the junction plant used for passing calls from one exchange to another can be obtained by introducing "storage" or "translation." Calls which must be passed through a number of intervening exchanges before they reach their destination require registers for "storing" a record of the number which is being called until a line to the required exchange is available. A feature of the new system is that these facilities are required only for one particular and infrequent class of call. For instance, local calls and those using direct junctions to neighbouring exchanges are controlled entirely by the subscriber's dial without the aid of translation, and only calls that are passed (or "tandemed") through intervening exchanges (usually few in number) require storage registers. Only very few numbers therefore require to be delayed through storage and a far quicker connection is thus established for the vast majority of calls. When all the direct junctions to an exchange are engaged, subsequent calls to that exchange are passed (or "routed") through a central exchange. This feature of the system is termed "alternative trunking" and can be employed to save a third of the junctions in the network. The system marks a definite advance on that at present in general use and is a remarkable achievement of electrical engineering.

Research on the Motor Car.

THE recently formed research committee of the Institution of Automobile Engineers is using a new instrument in investigating the problem of silencing. Tests have been made on a large number of brake drum and clutch plate materials, and work on cylinder and piston wear is being actively pursued. Research is also being carried out on the general problem of lubrication. In the course of this work a sample of used engine oil which had been running for 8,000 miles in a car was tested and compared with a new sample of the same brand of oil. It was shown that although the used sample gave much lower seizing temperatures than the new sample when first run in the machine, its performance rapidly improved until it was practically equal to the new. The temporary deterioration of the oil appears to be due chiefly to the water which had accumulated during the time it had run in the engine. This opens up a fresh field for investigation, for if deterioration was due to this cause alone, it appears to be quite feasible to provide means of purification from water on the engine, which may mean the reduction of oil consumption to one-eighth of the amount at present used.

This is among recent investigations conducted under the auspices of the Department of Scientific and Industrial Research and described in their latest report. The Council again calls for the increasing co-operation of manufacturers in industrial research. The experience of the last few years, the report continues, has shown that the installation of modern plant, the development of research work and the employment of educated staffs to be necessary if some industries are to compete in other parts of the world. Of all means of increased efficiency, the pursuit of research is often the most fruitful.

Reviews of Spring Books.

On Ancient Central Asian Tracks. By SIR AUREL STEIN. (Macmillan. 31*s.* 6*d.*).

Sir Aurel Stein's three journeys to Chinese Turkestan in 1900-1, 1906-8 and 1913-16 called for exceptional courage, skill and endurance; but their reward was proportionately great. His work has restored forgotten chapters to the annals of Asiatic history, and the relics recovered from sand-covered ruins have recreated civilizations of which the traces had vanished, except for the references of early Chinese travellers and the imperial annals. Sir Aurel Stein has already published from time to time detailed reports on the scientific results of his three journeys. In this volume he gives a summary account of all in a personal narrative; this follows the geographical rather than the chronological order in describing the sites visited and the results obtained by excavation. In the aggregate he covered twenty-five thousand miles, traversing the whole of the desert area of Chinese Turkestan with its borderlands towards China proper, and crossing the Pamirs from Kashgar southwards on his return.

Except for the scattered oases watered by glacier-fed rivers and capable of carrying only a small population, the area explored by Sir Aurel Stein is now entirely waterless. For his workmen water could be transported only in the form of ice blocks and the work of excavation consequently could be carried on only in the winter seasons. It has been held that this desert area has suffered a continued deterioration in climate, causing "dessication"; but Sir Aurel has found no evidence of any climatic change over prolonged periods. He holds that the disappearance of the oases and the decay of these ancient sites was due to the breakdown of the system of irrigation; while a shrinkage of ancient glacial ice is the cause of the present reduced river system. Before the development of transport by sea and more particularly in the early centuries of our era, the Lop desert and the Taklamakan formed the main artery of communication between China and the west. Sir Aurel Stein's important archaeological discoveries have revealed the measures taken by the Chinese to hold the entrance to the desert, both by garrisons and by the construction of a protective wall which Sir Aurel discovered and traced for a distance of four hundred miles from the Su-lo-ho basin to the Etsin-gol. The official documents on clay-sealed wooden tablets, some of them the oldest known examples of the Indo-Scythian script, afford evidence of the importance attached to this trans-desert route; it was held in turn by Chinese—in several periods—by Indo-Scyths and by Tibetans long before the area was overrun by Huns, Mongols and Turks.

Of archaeological results even this summary account presents a rich store. The most striking is the evidence, especially in the wall paintings and the paintings on silk of the T'ang period, of the extension of the influence of western art, Iranian, Greek and Graeco-Buddhist, to the area. Of the paintings on silk a large number were obtained from the temple store-house of a Taoist priest in the oasis of Tun-huang. Here, also, were thousands of early Chinese, Buddhist, and other manuscripts, of which a considerable number ultimately reached the British Museum. This was one of the author's greatest finds, for on examination the manuscripts were seen to include writings in previously unknown languages of which one, Tokharian, is a member of the Indo-Aryan group with, surprisingly enough, western affinities.

In this brief notice it has not been possible to do full justice Sotu Atir rel Sein's book. In style it is masterly; and as an exposition of archaeological and geographical discovery it receives every assistance from an abundance of illustration. The reproductions in colour of the Buddhist paintings are excellent.

Strange Happenings in Wild Life. By GEORGE HEARN. (Hutchinson. 15*s.*).

Mr. Hearn describes his book as "an album of a life-time's friendships." It is a fitting description. The book and its fine illustrations are the result of observations of wild life extending over twenty years; they form an intimate and fascinating record which will appeal to every nature lover. There are many popular accounts of observations in the field, but Mr. Hearn has struck an original note by selecting for discussion some quaint peculiarities of conduct among birds and other small creatures.

In a chapter on migration, the author mentions a deformed willow wren, which could never stand without straddling yet took part in the winter journey to Africa and safely returned on the spring migration. Few people can recognize the nest of the long-tailed field mouse; it is usually built in a slight hollow in the ground and resembles a tuft of grass. Occasionally one is built in a bush above ground. In nineteen years the author has discovered only four and their positions were such as to render photography impossible. The author's patience was at length rewarded, however, and he is to be congratulated on the remarkable photograph of a field-mouse about to leave its nest. As far as we are aware, it is the only photograph of its kind. The mouse had heard the approach of a marauding weasel and had intrepidly set out to decoy it from the nest of young. Mr. Heard was fortunate enough, quite by chance, to be on the spot. It is not perhaps generally known that many birds' nests serve a double purpose; they are frequently used as store cupboards by field mice in winter. The dexterity of the mice in climbing about the twigs of a hedge is remarkable. As the author says, they frequently use their tails, employing them with great skill as a means of balance. The photograph of a long-tailed mouse using a blackbird's disused nest as a dining-table is an interesting example of the author's patient camera work. The interesting fact that the red-backed shrike sometimes feeds its young with the eggs of small birds is recorded, and a photograph which is probably unique, illustrates this unusual habit; the photograph shows the parent bird with what is probably a common wren's egg in its beak.

A series of photographs showing the development of the cuckoo from the egg stage onwards is interesting. To obtain the series the author covered a distance of nearly three hundred miles in repeated journeys to the nest. There are two theories as to why the cuckoo does not build a nest of its own; one is that the birds' resemblance to the hawk causes it to be so harried by other birds that it finds it impossible to build a nest of its own with impunity. The other theory is that it would be a physical impossibility for the cuckoo to rear its large family, which consists of from six to twenty, the average being about nine. The young are large and phenomenally hungry. The author favours the latter theory. Another problem is how the cuckoo manages to have her eggs ready to deposit in a chosen nest at the right moment. The solution is that the cuckoo is

able to control her output and frequently retains the egg in the ovary at will. When circumstances are favourable there is an interval of forty-eight hours between the deposition of the eggs in various nests, but there are naturally occasions when there is no nest containing eggs or otherwise ready. Mr. Heard describes the ingenious way in which the cuckoo distributes its eggs, making repeated visits to the nests of her choice to learn of their condition; how she places the eggs in the nest, often in the face of angry attacks; and how, when hatched, the young cuckoo systematically ejects the young of its foster-parents. The author speculates on the origin of the "ejecting instinct," and the super-sensitiveness to touch of the young cuckoo. It is a curious fact that contact with the other young birds is so distasteful to the cuckoo that the bird is thrown into convulsive fits. The author suggests that the lack of suitable food supply accounts for many of the peculiarities of the English cuckoo, including the fact that the adult birds leave the country six weeks or more before the young birds are ready to go.

Other interesting chapters are entitled, "Tits and Their Intelligence," "Why Does the Wagtail Wag its Tail?" "How Does a Rat Steal a Hen's Egg and Get Away with It?" The author has a chatty style which is not inappropriate to his subject, but repeated references to Mrs. Blackcap, Dame Nature and so on become tedious. A second edition of the book will give the author an opportunity of correcting this, perhaps the only fault in a painstaking and instructive record.

Greek Coins. A History of Metallic Currency and Coinage down to the Fall of the Hellenistic Kingdoms. By CHARLES SELTMAN. (Methuen. 25*s*.).

Rome, so we are told, was not built in one day; neither was Greek art—in this book there is ample evidence of that, from the coins which are illustrated. Greek coins, moreover, are the most excellent miniature examples of art that exist. Coins, considered apart from their artistic aspect, however, are also historical documents, and as antiquities it is in this respect that they differ so much from pottery, engraved gems and statues. With Greek coins this is especially so, for they cover the field very fully, bearing upon domestic life, trade and religion, and in many cases by the absence of lengthy inscriptions their types and symbols have a special significance. The Greek coin, in the words of an eminent authority, "enjoys the advantage of being at once the best thing of its kind that Greek art could make, and an official document withal." What is more, the die engraver was often allowed to give free play to his fancy, in consequence of which the coins from his dies throw many attractive sidelights on contemporary life and times.

Even a brief perusal of this book should increase our regard for the Greeks as artists, for the Athenians—in particular—as economists, and for Alexander the Great as the most practical idealist in history. We are introduced to our subject by a short chapter on currency, money and coins. Metal when used to facilitate exchange of goods is currency; currency when used according to specific weight standards is money; money in the form of metal, weight deliberately adjusted and bearing the mark or device of a responsible authority, is coin. The world first learnt to value, next to weigh and last of all to stamp metal; by these stages barter gave place to a standardized system for the exchange of wealth.

The fourteen chapters which follow describe the rise and development of coinage extending over a period of seven centuries. It was from the Greeks of Asia that Greece herself learnt wisdom and expert craftsmanship, and during the eighth century B.C. coined money first began to pass from east to west with other civilizing influences. This influence of Asiatic Greece on European Greece was in full force by the seventh century B.C. and Ægina, about B.C. 670, began to issue coins with a leather-backed turtle as a coin type, most probably suggested by the presence of large numbers of these creatures in the adjacent seas. Following Ægina in the need of coined money, came Corinth and Megara, both of which were in sight of Ægina as was also Athens, where coinage commenced about B.C. 610. The Athenians, with silver mines on their own territory, had every inducement to adopt this new invention at an early date, although in the seventh century B.C. Athens was of much less consequence politically than either Ægina or Corinth. In turn we are taken through the development of the royal Lydian coinage and its successor, the imperial coinage of the Persian Empire, to glance at the issues of states on the north Ægina coast, and then, crossing the Balkans and the Ionian Sea, we hear of the money employed in the sixth century B.C. by the Western Greeks of Sicily and Italy. It is an interesting story, condensed in a most successful manner.

The coins issued during the Persian Wars, and those of the Athenian Empire, come in for consideration in their turn, followed by Corinth and her colonies, whose coins bearing Pegasus and the helmeted head of the goddess Athena were the one remaining rival to the money of Athens after the subjection of Ægina in B.C. 456; Tarentum, the wealthiest and most important of the Greek cities on the coast of Italy, celebrated for its coins depicting Phalanthus riding upon a dolphin, with horsemen in great variety on the reverses—"sometimes a fully armed rider, sometimes a boy jockey, now standing beside his mount, now leaping from it, crowning it with a wreath, kneeling beneath its belly or extracting a stone from its raised fore-foot"; Syracuse, in Sicily, where Greek numismatic art reached its finest and tetradrachms were signed by the great die engravers of the day so that their excellent work might gain commissions for them in the making of dies for other Sicilian cities; and so on, till we reach the fall of the Athenian Empire, which followed the issue of gold coins because of a shortage of silver, one of the indirect results of the Athenian expedition against Syracuse coupled with the desertion of slaves from the Athenian silver mines at Laurium, circa B.C. 410.

In a chapter devoted to coinage in the north and east, we are introduced to Macedon, Thrace, Lycia and Cyprus, with all the historical details which their coins present to us; in turn there is Boeotia (with the city of Thebes retaining the Boeotian shield as its coin symbol until her destruction by Alexander the Great), Thessaly, Peloponnesus, Crete and a score of other names which are familiar to those who can still recall something of the history of the ancient world. The outstanding historical characters are Philip of Macedon (B.C. 359), whose coinage became imitated in barbaric form as far away as Gaul and Britain; and Alexander the Great, a soldier as great as Julius Caesar or Napoleon but devoid of the sensuality of the former and the duplicity of the latter. Supreme as soldier, ruler and organizer, Alexander was an intensely practical man of action, especially brilliant as an economist, and it is mainly this aspect of his personality that we are permitted to study by the aid of his coinage. The history of the mints which he established in different parts of his empire give a brilliant picture of the scope of his conquests, and of his skilful employment of a uniform coinage as one means towards fostering the amalgamation of races. Alongside this coinage that of Athens or Syracuse

dwindles into insignificance, for vast quantities of wealth were dug from the mines of Macedon and released from the royal treasuries.

The closing chapters of the book deal with the coins of Ptolemy I (B.C. 305) and his successors in Egypt; the autocrats of Sicily; and the leagues and free cities of the Greek world, whose autonomous coins were struck while rival monarchs were holding out the bait of freedom in order to secure alliance and the consequent use of fortified posts in desirable territories. The science of Greek numismatics cannot be regarded as a dull subject if this book is read carefully, studying the coin illustrations provided on the plates, preferably with the aid of a map of the ancient world. It is a pity that such a map has not been provided; there is no other regret, unless it be that such a book as this has been so long awaited.

The Trail that is Always New. By WILLOUGHBY P. LOWE. (Gurney & Jackson. 16*s*.).

Mr. Willoughby Lowe is well known as a naturalist-collector. As Mr. D. A. Bannerman tells us in his introduction, the Bird Room of the British Museum has over 10,000 specimens acquired by him or by expeditions to which he was attached as collector. He has discovered numerous new species of bird, beast and reptile, as the appellation *lowei* in scientific literature shows.

The author's wanderings extend over a considerable portion of two hemispheres. He began as a boy of sixteen, when he joined a brother who was ranching in Colorado, where he spent nine years. Eastwards he has made expeditions to Siam and the Philippines, but the greater part of this volume is taken up with journeyings by sea and land in and along the coast of Africa, including Madagascar. These travels have brought him many adventures; they include the explosion of a muzzle loader, which, when young and inexperienced, he charged with modern smokeless powder: luckily he broke only his nose. In the Philippines he shot a rare butterfly (*ornithoptera trojanus*) and a python, with a right and left. Near Lake Baringo in East Africa he had a narrow escape from that dreaded snake the Black Mamba (*Dendraspis angusticeps*) which is said to be able to overtake the fastest horse. In the East African desert his party came near exhaustion from want of water. In Darfur he was in danger of being assassinated in a rising of fanatical Mahommedans. In Siam he narrowly escaped from a forest fire. Finally, in Madagascar he nearly succumbed after eating poisonous nuts.

On the voyage from Colombo to Penang Mr. Lowe encountered a mass of sea-snakes (*astrotia stokesii*), a rare and very poisonous species twisted thickly together: the mass was ten feet wide and the ship followed its course for sixty miles. Probably the snakes were breeding. On the Ivory Coast a Ringhal cobra was captured alive and spat its poison in the eyes of the author's companion, Mr. Ronald Hardy; he was in a critical condition for a week, but recovered. That snakes could spit poison was formerly considered only a native yarn, but this cobra when confined in a glass cage in the Zoological Gardens, attempted to spit its poison in Mr. Lowe's eyes: he could see the liquid trickle down the glass.

Among the rare birds and beasts collected by Mr. Lowe may be mentioned Napoleon's peacock pheasant from the Philippines; Rueppell's parrot from Angola, the female of which species is more brilliantly coloured than the male, and a giant swift, named after the author *Micropus aequatorialis lowei*, from West Africa. Mr. Lowe's discovery of British birds on migration or in their winter quarters is of special interest to British ornithologists. Records of the European swift in Darfur in June and in Madagascar on 31st July are very curious, for most swifts leave England during the first week in August. House martins and swallows he found in Gambia Colony in January, and one sandmartin, the only record, near Sierra Leone in February. And it must have been thrilling to hear the well-known call of the peewit in January near Khartoum. There are some really beautiful illustrations: we particularly admire those of the white-bellied sea eagle, drawn by the author's son, J. P. W. Lowe, who was accidentally drowned in 1931, and to whom the book is dedicated, and of the giant swift, by Mr. Grönvold.

As Mr. D. A. Bannerman says in his introduction "the days when a naturalist-collector can best serve the science he loves by accumulating specimens for study in our museums are fast drawing to a close. Instead we are now entering on a new era where camera and field notebook are supplanting gun and rifle." This is true enough, but the debt we owe to pioneers like Mr. Lowe is great. There are two maps showing the routes mentioned, but others giving more detail would be acceptable in any future edition.

What Butterfly is That? A Guide to the Butterflies of Australia. By G. A. WATERHOUSE. Illustrated by NEVILLE W. CAYLEY. (Australian Book Co. 12*s*. 6*d*.).

The popular literature of butterflies in this country is so old-established and extensive that it is difficult for us to realize the position of a youthful enthusiast in Australia who wants to identify his captures. True, twenty years ago Dr. Waterhouse, in collaboration with G. Lyell, produced a large and excellent work on the butterflies of Australia, but now he has given us a compact and complete handbook, the result of which should be to attract a large number of recruits to the study of these charming and beautiful creatures. There is a careful description of each of the 339 known species of Australian butterflies, with excellent coloured illustrations of most of them, showing both sexes and the underside, together with many good drawings of the larvae. The author tells us that only four new species have been added to the Australian list since 1914. This book should give such a stimulus to collecting in Australia that this number should be rapidly exceeded, though the mere discovery and characterization of new species is fortunately no longer the main object of entomologists. In the study of their biology there is practically unlimited scope. The author has collected all over the continent for forty years and gives us the benefit of his experiences. His advice on collecting and preserving is sound, simple and ample, as also the explanatory introduction, purposely expressed in the very simplest language. In the tropics it is very difficult to keep insects during the rains. Meeke, in New Guinea, overcame the difficulty by packing his setting-boards in a large iron box, round which he lit a fire to dry them quickly, after which he packed them in sealed tins. Incidentally, interesting items of information crop up. We learn that in Northern Queensland conspicuous flowering shrubs are rare and that South Australia is very poor in butterflies. Non-Australians are reminded to be careful in their names of places, for South Australia and Southern Australia are very different things. Their indiscriminate use has led to confusion and mistaken records.

It is interesting that the sclerophyll forests along the coasts of New South Wales and Victoria and part of northern Tasmania supports the older endemic butterfly fauna of Australia free from admixture of intrusive forms from the tropics; it is

especially rich in browns and skippers, few of which extend north of the Tropic of Capricorn. They are said to have an Antarctic origin. Tropical elements are working their way down southwards from New Guinea via the Torres Straits along the coast as far as conditions of climate and foodplant permit. They are chiefly found in the rain forests known in Queensland as scrub, in New South Wales as brush.

We have a few captious criticisms. On Plate I we are left to guess that the figures show the two sexes of a single species; what is worse, there is no explanation of the plates, and as there are thirty-four of these, each with numerous figures, it makes it troublesome to hunt up the names in the text. The popular names strike us as curious and unfamiliar. Are we to believe that the Australian public has created a popular entomological nomenclature? Apart from our homely English names, reasonably transferred to their colonial relatives, we find moonbeams and jewels, azures, flats, awls and darters, swifts, and even jezebels. These names are picturesque and often expressive, but is it really necessary to coin new ones, when the scientific terminology is there? We do not believe that scientific names will frighten collectors off butterflies any more than they drive gardeners away from flowers.

A glance at the plates suggests that the Australian butterflies, as a whole, are hardly more gorgeous than our own, but the magnificence of the intruders from the tropics introduces some of the glory of the Oriental Region, with which, indeed, the Australian has a good deal in common. These include some of the wonders of nature, such as *Papilio victoriae* of the Solomon Islands, which MacGillivray *shot*, because it was hopeless to catch these swift and high-flying monsters with a net. The females are over a foot in expanse. The author quotes the famous passage of Wallace, describing the intensity of his emotion when he first caught *Papilio priamus* in Batchian in 1859. "My heart began to beat violently, the blood rushed to my head, and I felt more like fainting than I had done when in apprehension of immediate death. I had a headache the rest of the day." The natives of the Solomon Islands tether them to their hair as ornaments. Brilliance attracts brilliance. We read: "A Bougainvillea in flower caught his attention and, though quite fifty feet or more above, it dropped perpendicularly on to this mass of bloom," to immolate himself on the altar of Science.

The Quest for Polar Treasures. By JAN WELZL. (Allen & Unwin. 10*s.* 6*d.*).

Jan Welzl found fame a year ago as the author of "Thirty Years in the Golden North." In his second book he continues the story of a life-time's adventures in the Arctic, and the two volumes form a record unique in the annals of Polar travel. Welzl is an illiterate trader and the story of his travels is the more remarkable because he can make no use of maps and has no knowledge of natural history. His story was dictated to two Czech journalists whose task as editors was no light one. Welzl's adventures were related in a disjointed manner as he recalled various persons and episodes, and Mr. Golombek and Mr. Valenba are to be congratulated on the continuity which they have so successfully achieved.

Welzl tells a graphic story of gold-digging in Alaska. "Men innumerable died of hunger with heaps of gold within their reach. Getting hold of machinery and transporting it to the diggings also cost piles of money. What was left people lost in various ways. And if then a man did not care to start again at the very beginning he could just shoot himself under the saloon's windows." There is a vivid description of travel over the tundra of Northern Canada. "A man who has not been there can scarcely imagine what a struggle with the tundra is like, when with only the light from their torches the exhausted hunters lift a sledge out of a trench, where the water has not yet completely frozen, and where the heavy sledge forces the man who is trying to push it up down to his chest in icy mud and water. The howling of the dogs mingles with the swearing of desperate men. How many have already died there from exhaustion, particularly those who have had the temerity to go alone! . . . The gold diggers who were with us had heavy boilers, machines, pumps and electric motors, besides enormous supplies of food, ammunition and explosives; and the whole lot sometimes fell ten or twenty times a day into holes full of wet snow and mud."

Tales of hunting in the interior of Alaska provide a thrilling chapter. Welzl many times made the treacherous journey from Kobrik Divide to the Mackenzie. It usually takes a month. First come sands, then forests, swamps, tundra and at last boundless fields of lava, stretching for hundreds of miles. The hunter who is bold enough to attempt this country must be well provided with water, paraffin and alcohol, for he will not find a mouthful of water or a chip of wood with which to make a fire and cook his food.

Jan Welzl has returned to the "Golden North," through the Canadian forests to Herschel Island and thence to New Siberia: "What will happen after that I don't know. I only know that I must be back in the North, where I shall not die of hunger while my old hands can get me a living."

The Mediterranean in the Ancient World. By J. HOLLAND ROSE. (Cambridge University Press. 8*s.* 6*d.*).

Professor Holland Rose's re-examination of ancient history from the sailor's standpoint is uncommonly interesting. Primitive man, he thinks, was only driven to sea by hunger. Fishing came later than hunting. Homer's Achæans, like many people of to-day, would only eat fish if they could not get meat. The Christian Church, it may be observed, had to enforce fish-eating on fast days by ecclesiastical penalties. But if men wanted to navigate the sea, the Mediterranean coasts had a fair supply of timber, especially pine, suitable for dug-outs and for the more workmanlike craft that succeeded them in the age of flint tools. The tunny is the chief edible fish of the Mediterranean, and tunny-fishing was, the author thinks, the early seaman's main aim. He went to the Euxine for cargoes of tunny to bring back to the rocky and barren Greek lands. As shipbuilding developed, metals were needed; the copper of Cyprus, the tin of Spain, the iron of Pontus were sought by hardy mariners, especially the Phoenicians, who for ages exercised a stern monopoly of Mediterranean trade. The Hebrew prophets knew of the ships of Tarshish in Southern Spain, that brought wealth to Tyre and Sidon. When Ezekiel speaks of the ships of Tarshish being broken with an east wind, he thought of them, so the author suggests, labouring homeward with a heavy lading of silver and tin so that they were unmanageable in a storm. Incidentally, Professor Holland Rose is sceptical about their bringing tin from Cornwall. But Mr. Hencken has recently shown that there is good evidence for a trade in tin between Cornwall and the mouth of the Loire, whence the metal reached the Garonne and by way of Narbonne was taken to Marseilles—by Greek rather than Punic merchants.

The author enters at some length into the story of Rome's

struggle with Carthage and her decisive though hardly won victory. He holds not without reason that Roman sea-power has been undervalued, and that Rome owed to her fleets no less than to her armies her conquest and long continued dominance of the Mediterranean world. Rome under the later Republic and Empire was dependent for existence on the regular supply of corn from Egypt and Africa, and therefore the Roman warships had to keep the trade routes clear. Professor Holland Rose gives some interesting details concerning the great corn ships, such as St. Paul journeyed in. They carried perhaps 300 people and a substantial cargo, and must have been of at least 400 tons burden. But they were difficult to handle in a gale because the masts and rigging were unduly weak. As the mainsail was made of oxhides patched together, it must have been very heavy and, in a high wind, must have imposed an enormous strain on the shrouds. The Romans built these big ships because they needed large supplies of corn, but it is significant that such ships were abandoned after a few centuries in favour of smaller and handier craft. An appended note in reference to the sea in Roman literature is strangely brief. It looks as if the Roman authors took sea-power as a matter of course, without troubling to understand it. The sea, to them, was an unpleasing and perilous element. It was pleasant for Lucretius to stand on the shore and watch the ships tossing in a storm. He did not know or care how those ships profited him and his countrymen.

The Exploration of Western America, 1800-1850. By E. W. GILBERT. (Cambridge University Press. 12*s.* 6*d.*).

When Napoleon sold "Louisiana" to the United States in 1803 for about £3,000,000, neither he nor the purchaser had any clear idea of the nature or even the extent of that immense territory which stretched northwards from the Gulf of Mexico to what is now the Canadian border and westward to the Rocky Mountains. The western part of "Louisiana" and the region beyond it to the few Spanish settlements on the Californian coast were blank spaces in Cary's map of 1806. Within the next half-century the blanks were filled by many official and unofficial explorers, at the cost of infinite toil and hardship. The nature of their task and the manner in which it was performed form the subject of Mr. Gilbert's able monograph, which is well planned and clearly written and is illustrated with many useful maps and diagrams. He first gives a geographical conspectus of the region, so as to show how its climate, rivers and vegetation, and aborigines, helped or hindered exploration. He then describes the main journeys, beginning with Lewis and Clark, who were sent by President Jefferson in 1803 to explore the north-western part of the newly acquired territory and who went up the Missouri and crossed the Rockies. Lewis and Clark, as the author says, deserve to be compared with Livingstone and Stanley in Africa for their courage and enterprise and for the importance of their discoveries. They were the first to realize the vast breadth of the American continent, and to find that, instead of a single mountain system west of the Missouri, there were two, separated by valleys at least 400 miles broad. Fur-traders followed in their steps and made their way to Astoria, near what is now Vancouver. It was a fur-trading party that in 1823 or 1824 discovered South Pass, the easiest crossing of the central Rockies. The Red River was explored by Lieutenant Pike in 1806, when he reached the mountain named after him as Pike's Peak. Further south the Sante Fé trail was opened up to California by two beaver trappers named Pattie in 1826-28. The region west of the Rockies was scientifically explored from 1842 by J. C. Frémont in a series of journeys, in the course of which he took part in the American occupation of Spanish California in 1846. Mr. Gilbert might perhaps have emphasized a little more strongly the hostility of the Indians to explorers, but it is true they suffered more from nature than from man.

Television To-day and To-morrow. By SYDNEY A. MOSELEY and H. J. BARTON CHAPPLE. Third Edition. (Pitman. 7*s.* 6*d.*).

Although among amateur constructors enthusiasm for television is steadily growing, the general public is, perhaps, largely unaware of the remarkable stage of development which this comparatively new science has reached. This may partly be because the B.B.C. transmissions are at present limited to half-an-hour on four nights a week, and take place at the incredible hour of 11 p.m., and it is partly due to a disappointing delay in making a modern vision receiver available to the public. Mr. Baird's latest model, in which the screen can be viewed by a roomful of "lookers," was demonstrated to the Press as long ago as last July, and the delay in marketing it is causing some misgivings. It is estimated, however, that there are already 10,000 "lookers" in this country, many of whom are operating home-constructed apparatus; and the excellent programmes transmitted from Broadcasting House have still further increased public interest. It remains for the manufacturers of vision sets to silence the sceptics by taking advantage of this goodwill in the near future.

Mr. Moseley and Mr. Chapple present a capable summary of the progress of television, from Mr. Baird's demonstration of his first crude apparatus to members of the Royal Institution in January, 1926, to the inauguration of regular transmissions by the B.B.C. last year. The early chapters deal with the history of television and the general details of vision apparatus. The "scanning disc" transmitter and receiver are described and the purpose of photo-electric cells and neon lamps is explained. Other important aspects dealt with include the tele-cinema and tele-talkies, the "Noctovisor" in which infra-red rays are employed to penetrate darkness and fog, and daylight and colour television. A chapter devoted to the latest developments deals with the new big screen, experiments with ultra-short waves, and the "mirror drum" which replaces the scanning disc and gives much increased brilliance in the image transmitted. In a concluding chapter the authors briefly review the progress of television abroad, which is being pursued on slightly different lines from that in this country.

This book should do something to increase public interest in television, and to remove misunderstandings which still exist in some quarters regarding the principles on which the invention is based. The book is well illustrated and the general reader will have no difficulty with the technical descriptions.

The Coast of Treasure. By LAWRENCE G. GREEN. (Putnam. 10*s.* 6*d.*).

This is an original book. The "coast of treasure" is the south-west coast of Africa. Just below latitude seventeen south is the mouth of the Kunene river, marking the frontier of Portuguese Angola and the former German colony of south-west Africa. The coast and the territory south of the river is called the Kaokoveld. Here are lost tribes of mysterious natives and bushmen "who may shoot with poisoned arrows at the sight of a white man." Through this unmapped region passed

the Boer trekkers in 1880, to return dissatisfied with their treatment by the Portuguese fifty years later. Mr. Green travelled up the Otjiwarongo, on the fringe of the Kaokoveld, in 1928 to meet the first convoy of Boers—the "Angola Trekkers"—and to write their story. He was given a copy of the only rough sketch of the Kaokoveld in existence. It showed the tracks of Major C. N. Manning, the daring native commissioner, who made it through more than a thousand miles of unexplored country. Along the Kunene river Major Manning noted on his sketch the hippo, crocodile, wild fowl, and the islands and safe crossings he had encountered. Southwards from the river, in this expanse of a hundred million acres, he had marked water holes and passes in mountain ranges which no white man perhaps had ever seen before. Even the Boer trekkers left nothing more than a waggon track in the Kaokoveld, "and the graves of their dead."

From the Boers Mr. Green learned something of the district and its inhabitants, and this knowledge was supplemented by an adventurer waiting to be tried on a charge of elephant poaching, and by policemen, government officials and traders.

Along the coast beneath the sea lie the skeletons of Dutch, Spanish, Portuguese and British ships. The author claims to have located the wrecks and tells of the treasures which are still washed up to the shore, and of the diamonds which lie buried beneath the sands on the "coast of treasure."

"When old hunters gather round the camp fires the talk is sure to turn to 'Ivory Valley'—the great cemetery to which dying elephants are said to make their way." The author believes that there are many such graveyards, and that each large herd has its own secret burial place. The evidence in favour of an Ivory Valley in the Kaokoveld is, he thinks, convincing. The man who has the good fortune to discover it will find rich treasure. Mr. Green points out that this legend is based on two well-known facts. The first is that the natives appear from time to time with heavy loads of valuable tusks which have not been cut from newly killed elephants. The second is that dead elephants, apart from those shot or trapped, are seldom found. Where do the dying elephants go? "They know that death is upon them; and trumpeting the shrill call of death they vanish into the secret valley where the huge skeletons of their forerunners lie whitening in the sun."

Mr. Green has a vigorous style and he has written more than a mere tale of adventure. It deserves, and will doubtless find, a large public.

Early Steps in Human Progress. By HAROLD J. PEAKE. (Sampson Low. 12*s.* 6*d.*).

Few archaeologists would have had the courage to attempt the formidable task that Mr. Peake has undertaken or the breadth of detailed knowledge necessary to accomplish it. He surveys the achievement of man in material culture from the first signs of constructive intelligence in the crudest stone implements to the working of iron. His book belongs to a class of study which was more familiar a generation ago than it is to-day. Yet it is precisely the type of work needed to stimulate public interest in the valuable contributions now being made by archaeologists to the study of civilization and its growth. The task of working out the broader implications of this study must, by force of circumstance, be left to others. Here, more particularly, Mr. Peake has been able to make skilful use of recent discovery in Egypt and Iraq.

After a brief sketch of the physical development of man and of the types and distribution of modern races, Mr. Peake traces the growth of man's material progress from every side—early tools, the use of fire, art, basketry, the domestication of animals, agriculture, the house, pottery, textiles, transport, metals, writing and trade. He brings out very clearly the crucial character of certain developments or discoveries, showing in particular the tremendous impetus in various directions given by the initiation of the agricultural mode of life. He never fails, when occasion arises, to point out how many elements in the life of to-day are rooted in prehistoric times as, for example, when he traces the dome, the Gothic cathedral and the Greek temple to types of habitation devised by prehistoric man. It may, perhaps, surprise some of his readers when they are told how many of the essentials of modern culture had been attained by the iron age and were developed little further until the eighteenth and nineteenth centuries.

As the author admits, his theories are sometimes highly speculative. At times, it might be added, they are highly provocative of argument. He is, however, scrupulously careful in stating the evidence upon which he elaborates.

Men Against Death. By PAUL DE KRUF. (Cape. 12*s.* 6*d.*).

Mr. de Kruf is the author of "Microbe Hunters" and "Hunger Fighters." In his third book he deals with the work of twelve doctors whose discoveries have had far-reaching effects on public health. Their names are not as familiar as they should be: they include Semmelweis, who conquered childbed fever; Branting, the discoverer of insulin; Minot, who fought against pernicious anaemia; and Finsen, Rollier and Strandberg, the "sun doctors." The book is based on a study of the original scientific contributions bearing upon the work of these twelve men, and the author has also studied the scientific reports revealing the state of knowledge before the discoveries he describes were made. Mr. de Kruf has had the advantage of knowing his characters personally, with three exceptions, which gives his study an intimate touch. It is a fascinating record of the ceaseless fight against death and the author has done justice to his task. Our only regret is the aggressively American literary style.

True North. By ELLIOT MERRICK. (Scribners. 10*s.* 6*d.*).

Mr. Merrick, formerly a journalist in New Jersey, has spent two years in Labrador living "the simple life," and there he intends to return. He worked for the Grenfell Mission as a school teacher, wood hauler and ships' crew. His friends, the scattered Eskimo families who inhabit the bay where the author made his home, were an interesting people: "Scottish Presbyterian in religion, old English in speech and customs, Eskimo when it came to seal fishing and dog driving, Indian in their methods of hunting and their skill with canoes." It is a refreshing story of simple contentment: "Every bit of work we do seems worth doing. We catch our fish and eat them. We build things and use them. Most of the things we cannot make or find or improvise we have to do without, and this makes our creations of tremendous satisfaction. We feel so close to things that at night we could no more fall asleep without going outside to touch the wind and the dew, look at the dark trees and the sky, listen to the bay, than you could go to bed with your shoes on." Mr. Merrick has found the perfect retreat from "a million other peoples' noise."

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